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THE COUNTRY HANDBOOKS—II

Edited by Harry Roberts

The Motor Book

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THE KING'S 22-H.P. DAIMLER CAR

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The Motor Book

By R. J. Mecredy

Editor of The Motor News

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Editor's Note

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The MOTOR BOOK

Introductory

THE art and pastime of motoring appeals to almost every class in the community, from the point of view of pleasure, convenience, or utility. When, in 1896, the Emancipation Day run to Brighton, in commemoration of the new Act, was held, the public were mildly interested, but more from curiosity than from a belief that the new movement was one likely to assume large dimensions, and the results of that run seemed to confirm them in this belief. Those, however, who thoroughly understood the question realised that there were the germs of a mighty development in the new means of locomotion, and the results up to the present have certainly borne out this idea. These results, however, are but the first fruits of a development which even at the present day few fully realise.

As a pleasure-vehicle the motor car appeals to every man of means. Those who have never motored are inclined to scoff, and refer to the cars as noisy, evil-smelling nuisances, in no sense to be compared to a thorough-bred horse. They lose no occasion for running down the

new pastime, and are surprised at their friends gradually adopting it. This state of mind continues until they are persuaded to try a run, when their feelings undergo a rapid change, and within a short space they become enthusiastic motorists themselves. Nor is this strange. The sense of power and control is delightful; the sensation of flying at a fast speed through the air is not afforded by any other means, while the convenience and usefulness of the new vehicle are beyond question. Space and time are almost annihilated, and journeys which previously occupied the best part of a day, can now be performed in an hour or so. From a hygienic point of view, too, the new pastime in beyond all praise. Properly clad, it is impossible for anyone not to derive benefit from motoring. The rush through the air is exhilarating in the highest degree, and has the effect of keeping one in the best possible health, especially if there is any tendency to lung troubles.

From the utilitarian point of view, however, there is even a wider field, and in process of time the motor will undoubtedly take the place of the horse for every class of traction, except farm work. Already in Paris there is an immense number of light vans used by the principal shops. It is found that these are cheaper, more convenient, and of course much quicker than the ordinary horse-drawn vehicle. When the demand

is sufficient to enable such vans to be standardised and made in huge numbers, the price will be greatly reduced, and their use will then become almost general. For heavy traffic the same applies. Notwithstanding the high price of the large vans and of lorries, they have been already adopted economically and satisfactorily by many firms, and with increased efficiency and decrease of cost, they are bound to oust the horse eventually.

For passenger vehicles the field is even wider. To the business man time is money, and in large cities such as London the loss of time entailed in travelling between one's office and one's home, makes a sad hole into the working hours of the day. In country districts where railway facilities are not good, and where there is not sufficient traffic to warrant the laying down of light railways, the advantage will be just as great, while in the tourist districts, the slow and cumbersome coach is sure to become a thing of the past. All road locomotion will thus be expedited, and the effect in such large cities as London, in relieving the congestion, will be very marked. Take, for example, the motor 'bus, as compared with the horse-drawn vehicle. It has little more than half the length, taking the horses into account; it can travel at three times the pace, and can start and stop more quickly. As a result, in any given street with the same amount of passengers, the

congestion will be reduced by more than one-half.

Twenty years hence, very few horses will be seen in the streets of London. It goes without saying that from a hygienic point of view this will be a very vast improvement indeed.

The general public still labour under the delusion that the motor car is a most complicated piece of machinery. In this they are very far astray. The modern petrol car is so simple that any man of ordinary common sense can run it satisfactorily, if he will but utilise that common sense to master its peculiarities, and give it the regular attention which it needs. The principle is practically the same in all the petrol motors, from the bicycle to the largest car, and if the reader will take the trouble thoroughly to grasp and understand the first chapter of this book, he will be sufficiently grounded to enable him to reason out the why and wherefore of every part of what at first glance seems to be a very complex combination. He must dismiss from his mind the notion that the motor car is a sort of automatic machine, which only requires filling up with petrol, oil, and water, and the manipulation of certain levers and pedals. Like a horse, it requires a certain amount of regular attention, and if it receives that attention, it can be relied upon to do its work well and reliably, and seldom to need repairs or replacements.

Introductory

The simplest way to master the principles of the internal combustion engine is to imagine oneself mounted on a bicycle, and then compare the combined machine and rider to the petrol engine, as is done in the first chapter of this book. The next important fact to impress upon one's memory is that every moving or sliding part requires lubrication, and that if it does not receive it, serious damage will result. Also, that all bearings, connections, etc., must be kept adjusted, so that there is no play or side shake, if wear and efficiency are to be secured. These are really the most vital points for consideration, for in other respects a good car is almost fool-proof.

The Motor

THE principles of the internal combustion engine are no doubt familiar to most of my readers, but in case there are some who do not understand the system, I shall describe it fully. The power is obtained by the explosion of a volatile spirit in a chamber at the top of the cylinder. This explosion drives the piston downward, and so revolves the crank shaft and flywheel, just as a bicyclist, when propelling his machine, exerts pressure on the pedal which happens to be uppermost, and in doing so, revolves the crank axle and chain wheel, and so, by means of the chain, transmits power to the hind wheel of the bicycle, and causes it to revolve.

THE OTTO SYSTEM

The system adopted in the internal combustion engine is known as the "Otto," or four-cycle system, and it is so called because there are four reciprocations of the piston for each explosion or propulsive effort in the combustion chamber.

With the aid of four diagrams, I shall now explain this system, but would first point out that these diagrams illustrate the ordinary air-cooled engine, fitted to cycles. For cars, of course, the

engine is water-cooled, and has, as a rule, two or more cylinders. The general design is however the same.

The Suction Stroke.—To start the engine it is

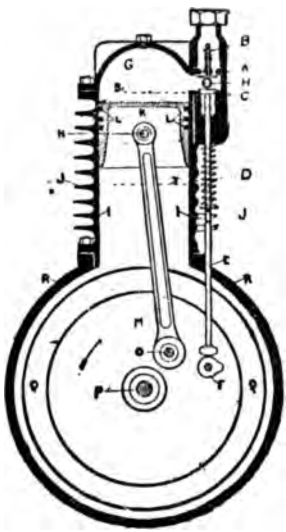


FIG. 1.—SUCTION

necessary to revolve the flywheel Q, which in turn operates the connecting rod M, and so causes the piston K to travel up and down, and suck in a charge of explosive mixture. In the case of the motor bicycle this is done by pedalling the machine forward so that the bicycle drives the engine. In the case of a car a starting handle is

fitted to the end of the crank shaft, and when operated vigorously revolves the flywheel.

Now, in fig. 1, the piston, which at its highest point reaches the dotted line S, is just about to

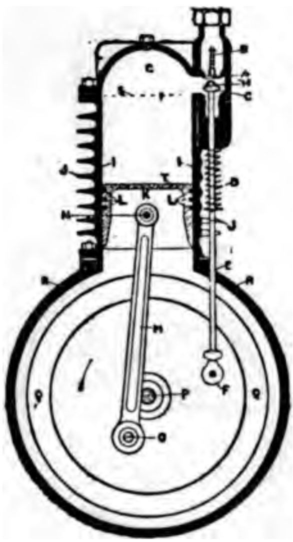


FIG. 2.—COMPRESSION

descend. As it moves downward it creates a vacuum in the combustion chamber G, and this vacuum sucks open the inlet valve A, which is connected by means of a pipe with the carburetter, where the crude vapour and air are mingled to form an explosive mixture. As the piston descends, this explosive mixture continues to rush

in until not only the combustion chamber but the top half of the cylinder is full. When the piston reaches the lowest point, the spring B draws the inlet valve back on to its seating, and the cylinder

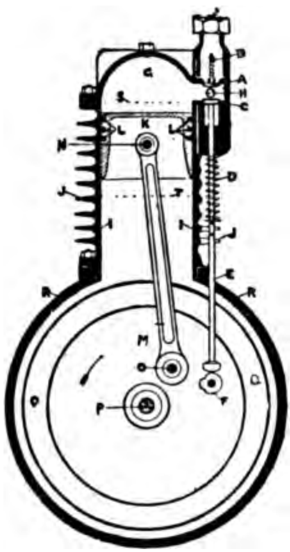


FIG. 3.—EXPLOSION

head and combustion chamber become gas tight once more. This completes the suction stroke.

The Compression Stroke.—Fig. 2 illustrates the compression stroke. The piston having reached the lowest point is just beginning to ascend again, the inlet valve of course remaining shut. As the piston rushes upward in the cylinder, it drives

the explosive mixture before it, and finally compresses it into the combustion chamber C, ready for the explosion which is to produce the propulsive force.

The Explosion Stroke.—Just as the piston reaches the highest point in the cylinder, and the gases are compressed to their utmost, a specially designed mechanism (which will be hereafter described under "Ignition") causes a spark to pass at the sparking plug H, which ignites the charge and produces a sudden and violent expansion of the gases. This operates on the top of the piston, just as it is about to descend, as shown in fig. 3, and imparts momentum to the flywheel. The action may be compared to the pressure exerted by the cyclist on the pedal, which causes the crank axle and chain wheel of his bicycle to revolve.

Fig. 3 shows the piston thus descending from the force of the explosion, and it will be noticed that both the inlet valve B and the exhaust valve C remain shut, so that there is no escape for the expanding gas, except in a downward direction. The crank with the flywheel combined move as in fig. 1, in the direction of the arrow, but whereas in fig. 1 the power was supplied by the effort of the motorist, in fig. 3 it is caused by the explosion.

The Exhaust Stroke.—The piston continues its descent until it reaches the lowest point of the

cylinder, and at this stage a specially-designed mechanism (which will be hereafter described) causes the exhaust valve C to open. A moment later the piston begins to ascend once more under

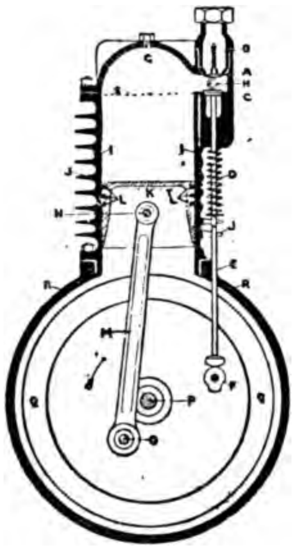


FIG. 4.—EXHAUST

the force of the impetus communicated to the flywheel by means of the explosion. Fig. 4 shows the piston as it is about to ascend. At this stage the combustion chamber and the top of the cylinder are filled with the products of the explosion, and as it ascends the piston drives these waste products before it, and ejects them forcibly

through the open exhaust valve C. When the piston reaches the highest point, S, the mechanism already referred to closes the exhaust valve, and the combustion chamber is left practically clear of the exhaust gases and ready to receive a fresh charge.

This completes what is known as the "Otto Cycle." The piston then immediately begins to descend once more under the impetus imparted to the flywheel, and the whose series of operations recommences.

THE ENGINE

I shall now proceed to describe the various parts of the engine. K is the piston, which is made a perfect sliding fit for the inside of the cylinder I. Round this piston are circular slots into which are fitted split rings L, which form a touching contact with the sides of the cylinder, and so prevent the gas from escaping between the walls of the cylinder and the piston. The construction of the piston and its rings will be more fully described later on.

N is the pin on which the connecting rod M of the piston works—it is generally known as the gudgeon or wrist pin. O is the pin on which the other end of the connecting rod M works, commonly called the crank pin. This pin is mounted on the flywheel Q, which is formed of two discs facing each other, with the connecting rod M

MR S. F. EDGE AND HIS 16-H.P. NAPIER CAR

between them. The construction will be better followed in fig. 5. In some cycle engines, and in all motor-car engines, the flywheel is fixed to the motor shaft outside the base chamber, and in the case of cars is generally utilised for the female portion of the friction clutch. The crank, in the bicycle engine represented by the distance between O and P, is really part of the flywheel, and the latter is consequently revolved by the action of the piston. P is the crank or engine shaft on to which the flywheel is keyed, and this shaft carries at one end a pulley, which (in the case of a tricycle or a bicycle with chain drive a cogwheel takes the place of the pulley) drives the belt, and it in turn drives the hind wheel of the bicycle. In the case of a motor car, the flywheel takes the place of this pulley. At the other end of the shaft is a cogwheel Y (fig. 5), which through the medium of W and X works the cam F that raises the exhaust valve, as described under "Exhaust Valve." R is the crank or base chamber to which the cylinder is attached. The engine is lubricated by allowing a certain measure of oil to flow into the bottom of this crank chamber, which is splashed up by the action of the flywheel and crank. In most cars, oil is also fed direct to the side of the cylinder. The dotted line S indicates the highest point in the cylinder to which the top of the piston ascends, and T the lowest point to which it descends.

JJ are ribs, or radiating flanges, which are cast on to the sides of the cylinder and combustion chamber with the object of diffusing the heat from the latter as rapidly as possible, and of exposing a large surface to the cooling effects of the air. In the case of motor cars water is used for cooling purposes.

A is the induction valve to which a pipe from the carburetter (where the explosive mixture is formed) communicates, and this valve is held in position by a spring, B, until the suction of the engine overcomes the resistance of the spring. C is the exhaust valve, which is held in position on its seating by the spring D until the operation of cam F pushes the valve upwards in order to allow the exploded charge to escape. H is the sparking plug, by means of which the electric spark is made to occur in the cylinder, and so ignite the charge.

The wheels operating cam F are not shown in diagrams 1, 2, 3 and 4. In fig. 5, however, they are very clearly indicated, and the action is very fully explained under " Exhaust Valve."

I might explain that this same two-to-one shaft has a second cam on the extreme end of it, as depicted in fig. 5. This cam works the ignition, which, like the exhaust valve, comes into operation once in every four reciprocations of the piston. It takes effect in the third cycle illustrated, whereas the opening of the exhaust takes effect in the fourth.

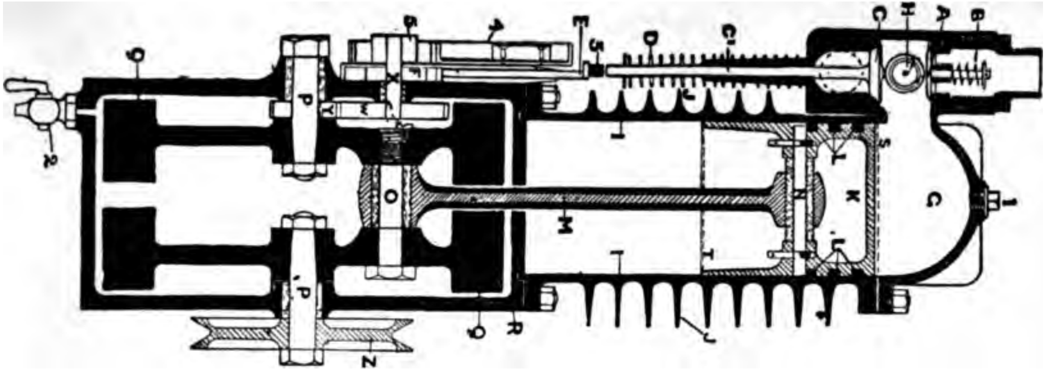


FIG. 5.—SECTION OF SINGLE CYLINDER ENGINE

A, Inlet Valve; B, Spring holding Inlet Valve on Seating; C, Exhaust Valve; C 1, Stem of Exhaust Valve; D, Spring holding Exhaust Valve on Seating; E, Plunger operating Exhaust Valve; F, Cam raising Plunger; G, Combustion Chamber; H, Sparking Plug; I, Sides of Cylinder; J, Radiating Flanges; K, The Piston; L, Piston Rings; M, Connecting Rod; N, Gudgeon Pin; O, Crank Pin; P, Crank or Motor Shaft; Q, Flywheel; R, Crank or Base Chamber; S, Highest point Piston reaches; T, Lowest Point; W, Gear Wheel working Two-to-one-Shaft; X, Two-to-one Shaft; Y, Gear Wheel on Motor Shaft, which meshes with W; Z, Driving Pulley; 1, Aperture for Compression Tap; 2, Waste Oil Outlet; 3, Exhaust Valve Lifter; 4, Contact Breaker; 5, Cam operating Trembler in Contact Breaker.

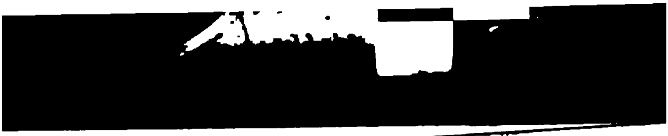


Fig. 5, which gives a sectional view of the engine, should be studied in conjunction with the preceding diagrams, and also with the diagrams under "Exhaust Valve" and "Contact Breaker."

The piston is clearly shown in fig. 5. It is composed of an iron casting, which is made a good sliding fit in the cylinder; around its upper end square-bottomed grooves are cut; in these the piston rings fit. Each ring is made of cast-iron, and the bore being eccentric to its outer diameter, there is a certain amount of spring in it, and so a gentle pressure is kept against the cylinder, preventing any of the expanding gases passing the piston. The piston is made as light as possible, there being a certain loss of power in the stopping and starting again at each end of the stroke.

THE MECHANICALLY OPERATED INLET VALVE

Quite recently the mechanically operated inlet valve has come into vogue, and is even being used in the case of small single-cylinder engines. Fig. 6 illustrates the latest pattern of Minerva 2-h.p. engine for motor bicycles, and gives an excellent idea of the general principle involved, though in larger engines built for cars a separate cam shaft is generally fitted. The illustration gives a side view of the engine, with the valve chambers in section. The piston and the other working parts of the engine itself are not shown.

G is a partition between the two valve chambers, the inlet valve being that to the left, and the exhaust that on the right. H is the pipe leading from the carburetter to the inlet valve. S is the valve stem. I is the outlet pipe leading from the exhaust valve to the silencer. The explosive mixture enters through pipe H, passes through the inlet valve when opened, goes into the cylinder, is exploded, and the waste products are driven out through pipe I.

M is the cam which lifts the valve stems, and the manner of doing so we will explain presently. N is the half-speed shaft on which the cam M is mounted. O is the main shaft of the engine, which drives the half-speed shaft N. P is the exhaust valve. The cam operates the inlet valve S by lifting up the rod V, which works vertically in the socket W. The arrow shows the direction in which the cam travels. When the widest part of the cam comes under rod S this is lifted and the valve opens; then as the cam continues on its course the rod gradually slides down and the valve shuts. The exhaust valve P is also worked by cam M by means of the bell crank T. This swings on the pivot U, and when moved by the cam lifts up the rod Q which moves in the guide R.

The cam M has half its thickness cut away, and so as to form two profiles. In fact, it may be said to form two cams, one larger than the

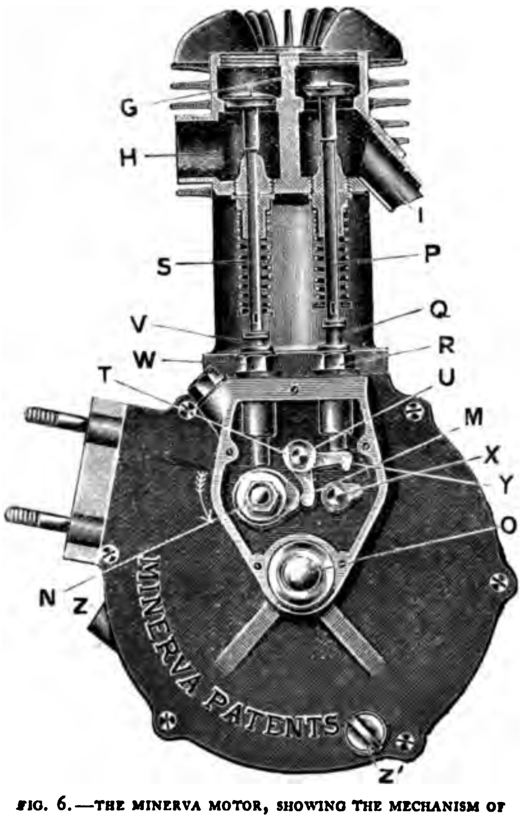
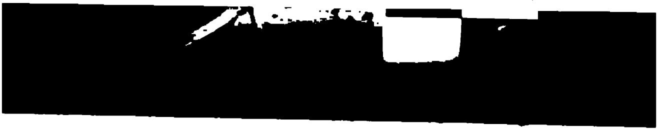


FIG. 6.—THE MINERVA MOTOR, SHOWING THE MECHANISM OF THE VALVES



other. The large cam controls the exhaust valve P; the smaller works the inlet valve S. Thus the exhaust valve is held open for a longer period than the inlet.

Another cam X works on a pivot, and is controlled by a lever worked by the rider. This cam raises the arm Y of the bell crank U, and so holds the exhaust valve open as long as is desired. Z shows where the lubricating pipe is fixed to, and Z 1 is the waste oil outlet.

The ordinary automatic inlet valve is held in its place by a spring, as already described, and is lifted by suction. The piston on its down stroke causes a partial vacuum in the upper part of the cylinder, called the combustion chamber. The inlet valve is therefore drawn open, and the explosive mixture rushes in. When the suction ceases, the valve closes by means of the spring, which has to be nicely tensioned to give the proper amount of resistance.

The mechanically operated valve, as we have seen, opens at a set time and closes at a set time, because it is operated directly by the engine.

With the automatic valve the time of opening and its duration depend to some extent on the force of the suction exercised by the piston. If the suction is strong, the valve opens quickly, letting in a big charge. When the suction is weak, the valve opens feebly and at a later period. The mechanical valve always opens at the same

moment. It must be borne in mind, however, that when the piston begins to descend, the suction is very slight, and consequently even if the valve did open at once the amount of mixture drawn in would be small. Also, owing to the slow speed of the engine, the mixture (except the newest type of carburetter is fitted, as in the case of the Panhard) would consist mostly of air. With the automatic valve the suction, when it comes, is sudden and strong, and from the moment the valve opens the maximum quantity of perfectly proportioned mixture is drawn in. Consequently on this score the advantage in favour of the mechanically operated valve is trifling.

The situation may be summed up by stating that the mechanically operated valve has the following advantages :—

Easier starting, owing to the valve always opening (automatic valves sometimes stick).

Certainty of action.

Simplicity. No adjustment of springs, etc., needed.

On the other hand, there are several disadvantages, viz. :—

Additional cost of production.

Additional complication in manufacture.

Extra cam shaft and gear, meaning additional wearing parts and increased difficulty in getting at the valves.

Experts are of the opinion that the new valve

A CAR OF THE SPEEDWELL MOTOR COMPANY

will be of undoubted value on large engines, but cannot say yet whether in smaller engines the advantages will not be counterbalanced by the drawbacks. However, it is a very significant fact that such a firm as the makers of the Minerva should pin their faith to the new valve. They have fully tested it, and seem willing to abide by the result, claiming, indeed, a substantial increase in power.

MULTICYLINDER ENGINES

As already mentioned, engines are either one-cylinder, two-cylinder, or four-cylinder, and in a few cases a three-cylinder engine is fitted. In the single-cylinder engine, the explosion or propulsive effort only occurs for every four reciprocations of the piston. In the two-cylinder engine there is an explosion once for every two reciprocations, and in the four-cylinder engine there is an explosion for each reciprocation. Each single cylinder, however, is practically a duplicate of the other.

Fig. 7 shows a cross-section of the 12-h.p. Daimler motor, which it would be well to study in conjunction with the drawing of the single-cylinder engine which appears elsewhere. The former is air-cooled and the latter water-cooled, the water entering through the pipe marked B 6, and after traversing the water jacket, emerging

through B 5. The mechanically-operated governoı too, is a refinement which does not appear in th single-cylinder engine. The lever T I operate the throttle which regulates the amount of mixtur

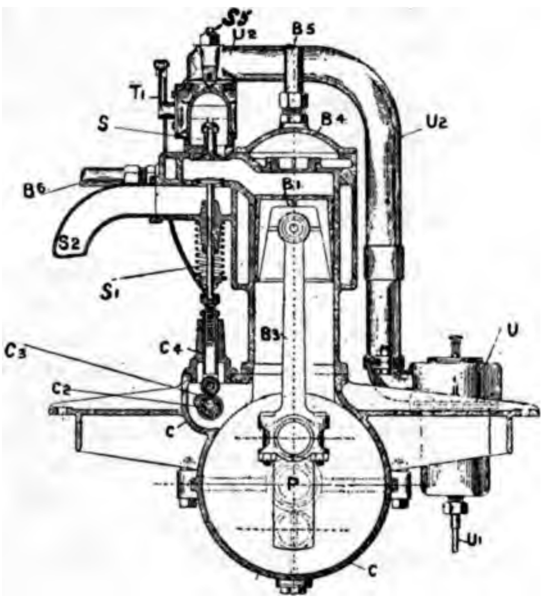


FIG. 7.—CROSS SECTION OF 12-H.P. DAIMLER MOTOR

finding its way through the inlet valve S. C is the two-to-one shaft, and C 3 the cam whic raises the exhaust valve, in the same way as the case of the single-cylinder engine. U is tl spray-carburetter, with inlet-pipe, U I. Tl mixture ascends through the pipe U 2.

Fig. 8 shows the four cylinders of the 12-h.p. motor, of one of which fig. 7 gives a cross-section. Two of these cylinders are shown in section, so as to give an opportunity of inspecting the working parts. The crank P, the connect-

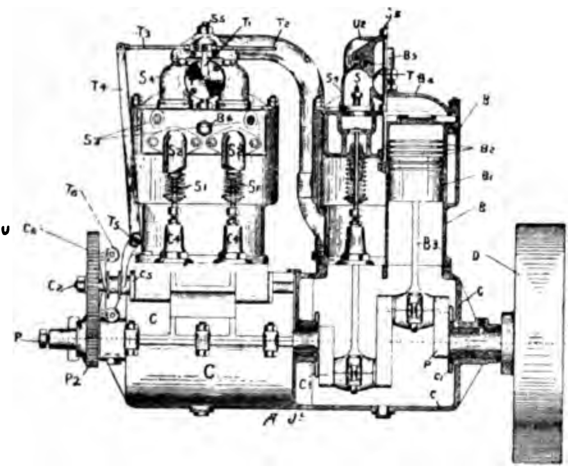


FIG. 8.—SIDE ELEVATION AND SECTIONS OF 12-H.P. DAIMLER MOTOR

ing-rod B 3, the piston B 1, the piston-rings B 2, and the water-jacket B, are all very clearly shown. The operation of the governor can be clearly followed, but in this connection we should advise the reader first to run through the section of this chapter dealing with the systems of governing, but more especially throttle-governing. P 2

is a pinion fixed on the motor shaft, and meshing with C 6, another pinion twice its size, and to which the governor mechanism is attached. When C 6 is revolved rapidly, the governor-balls, T 6, fly outwards and push the sleeve fixed on the two-to-one shaft, C 2, towards the engine, and this sleeve in turn operates the lever pivotted on T 5. This lever operates the rods T 4 and T 3, and through them the lever T 1, which in turn regulates the throttle-valve T, and so controls the amount of mixture passing to the engine. S 3 shows the apertures for the sparking-plugs, and S 2 the exhaust-pipes, cut away so as to leave an uninterrupted view of the exhaust valve stems S 1. D is the flywheel, which is revolved by the crank-axle, and in turn communicates the power to the driving-wheels through a friction-clutch and train of gearing.

The diagram of the four-cylindered engine illustrates the two-cylinder equally well. Of course the latter has only two impulses for every two revolutions of the flywheel, whereas the four-cylindered engine has four impulses for every two revolutions, and consequently runs much more smoothly. The timing of the firing stroke depends upon the angle at which the cranks on the crank shaft are set. This angle may be either 180 or 360 degrees. Where the cranks are set at 180 degrees, the two cylinders fire immediately one after another, so that during

one revolution there are two impulses, and at the next no impulse. If the cranks are set at 360 degrees an impulse occurs at every revolution, but in this case the cranks must be balanced to counteract the vibration set up by all the parts moving in the same direction at the same time.

The following is the sequence in a two-cylinder engine when the cranks are set at 180 degrees:—

First cylinder.	*Second cylinder.*
Suction	Exhaust.
Compression.	Suction.
Firing.	Compression.
Exhaust.	Firing.

When the cranks are set at 360 degrees the following is the sequence :—

First cylinder.	*Second cylinder.*
Suction.	Firing.
Compression	Exhaust.
Firing.	Suction.
Exhaust.	Compression.

THE EXHAUST VALVE AND TIMING GEAR

The function of this mechanism is two-fold. It has to raise the exhaust valve at that particular point of the travel of the piston which will allow the waste products of explosion to escape to the best advantage. If the valve is opened too early, the charge will begin to escape before its full

power is expended, and if too late, the piston will be working against a heavy back pressure. In either case, there will be a loss of power. The second function of this mechanism is to time the

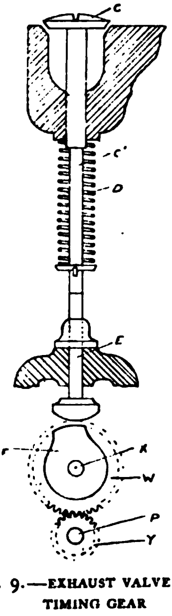


FIG. 9.—EXHAUST VALVE AND TIMING GEAR

electric sparking, so that it will occur in the combustion chamber at the correct moment. I shall deal first with its operation in connection with the exhaust valve, and would ask my readers to consult figs. 5 and 9 when following our description. Y is a small gear wheel fixed to P,

the crank shaft of the engine. This wheel meshes with another wheel, W, which is exactly double the size. Consequently W only revolves once for every two revolutions of the crank shaft P. X is the shaft to which this wheel is fixed, and it is commonly known as the half-time, or two-to-one shaft. Now, on X is fitted a cam F, with a projection which lifts the plunger J once in every revolution of X. J in turn acts on the valve stem C 1, and so lifts the valve C off its seating, as depicted in fig. 9, and allows the exhaust gases to escape. Needless to say, the projection on F only acts on J once in every two revolutions of the crank shaft P, or in other words, once for every four reciprocations of the piston.

The timing mechanism is also mounted on shaft X. It consists of a cam 5 (fig. 5) which, as will be described under "Ignition," completes the electric circuit at the correct moment, and so causes the spark to pass in the combustion chamber.

THE IGNITION

The methods for firing the explosive mixture in the combustion chamber may be divided into four heads. The first and most important is :—

(1) *By means of primary cells with coil*

The mechanism necessary to produce the spark under this system is as follows :—

1. The Battery, which originates the current.
2. The Induction Coil, which intensifies it.
3. The Switch, for breaking the electric circuit.
4. The Connecting Plug, which acts the part of a removable switch, but which is being gradually discarded.
5. The Contact Breaker, or Commutator.
6. The Sparking Plug.

To understand the system properly, it is necessary to describe these parts in detail.

1. *The Battery.* — Batteries are divided into primary and secondary. The primary battery is commonly called the dry battery, and generates its own current: the secondary battery is called the accumulator, because it receives and stores the electric current received from a dynamo or other source. A dry battery is useless when run out, but an accumulator can be recharged, and will last for years. As a rule, the dry battery consists of four cells, which should register when new, 1.5 volts each, or a total of 6 volts for the whole battery. When the total voltage drops below 4, the battery as a rule becomes inoperative. The amperage, when the battery is new, should be between 9 and 10, and after it drops below 2, it will no longer work.

The accumulator usually consists of two cells, which should register 2.2 volts each when new, or a total of 4.4 for the whole battery. When it drops below 4, it should be recharged.

DE DION-BOUTON 6-H.P. CAR, WITH FRENCH-BUILT VICTORIA CARRIAGE BODY

2. *The Induction Coil.*—The object of the coil is to increase the pressure or voltage so as to enable the spark to jump the space between the wires of the sparking plug. It consists of a wood or vulcanised case, inside of which is a bundle of soft iron wire, enclosed in a vulcanite tube, or otherwise insulated. Round the insulation of this coil of wire is wound a number of coils of thick, insulated wire, known as the primary winding, and further insulation is placed between each successive layer. One end of this wire is fixed to the inside end of the terminal. The other is either connected to another terminal, or fixed to another wire round the coil, the former being the more general method. Over the primary winding a thick insulation is placed, over which a number of coils of fine insulated wire are wound. This is known as the secondary winding, and is not in any way connected with the primary. Each end of this wire is connected to a terminal as a rule, though it may be turned to earth by the brass band round the coil.

The principle upon which the coil works is that when an electric current is passed through an insulated coil of wire wound round a soft iron core, the latter becomes a powerful magnet, which exerts its influence in the space round the magnet, the lines of force flowing from the north to the south pole. If several coils of fine insulated wire are wound round the primary winding of the coil, so

as to come within the magnetic field, an induced current of high tension is set up within the coils in the opposite direction to the low tension current. This current is the result of the lines of force cutting the convolutions of the secondary coil.

3. *The Switch.*—An arrangement for enabling the driver to break the circuit and so prevent the current from running to waste.

4. *The Connecting Plug.*—This is really a removable switch, intended to act as a permanent disconnecter. In most cars, however, it is dispensed with, the fixed switch being considered sufficient.

5. *The Contact Breaker, or Commutator.*—The object of this is automatically to make and break the continuity of the low tension circuit, so as to cause an induced high tension current to flow, and thus produce a spark in the combustion chamber. There are two types, one commonly known as the contact breaker, fitted to small, high-speed engines, and the other termed the commutator, though the contact breaker is often referred to as a commutator.

There are two types of contact breaker. In the De Dion type contact is made and broken by means of a flat vibratory spring known as the trembler.

With the aid of the engraving I will endeavour to describe this operation. To begin with, as already explained, the contact breaker is operated by the two-to-one shaft. H (fig. 10) is simply a pear-shaped section of insulating material. E is a

cam worked by the two-to-one shaft, and which consequently revolves once for every two revolutions of the motor shaft. T is the trembler. It

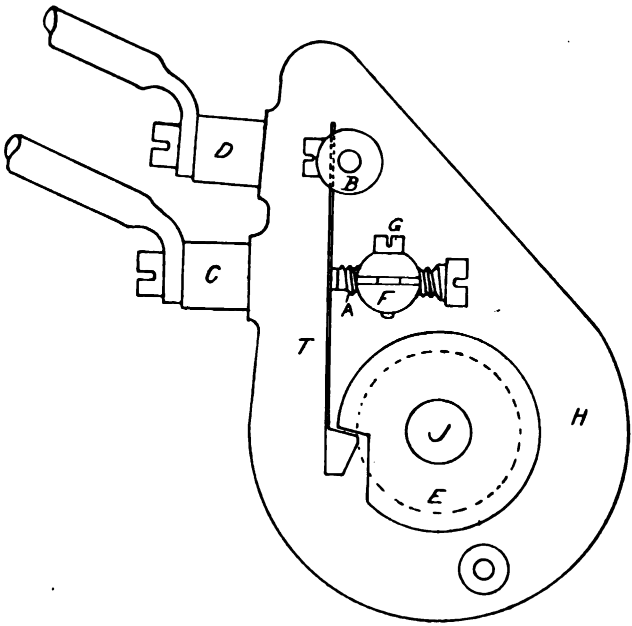


FIG. 10.—THE DE DION CONTACT BREAKER

has a wedge-shaped piece of metal fixed to one end, and when the wedge rests in the slot, as depicted in the engraving, the centre of the trembler should rest against the end of the screw marked A. The end of this screw is covered with platinum, as being a conducting material,

and the part of the trembler against which it impinges also contains a blob of platinum. F is the stud through which A is screwed, and G is a screw securing it firmly in position. The other end of A is in contact with the bolt to which the lower wire is attached. B is another bolt securing the trembler by means of a set screw to which the upper wire is secured.

Now, supposing the plug and switch are in position, the current flowing from the positive pole of the battery will run through the screw A, thence into the trembler, from the trembler through screw B, and thence to the wire which is earthed or attached to the frame, and so through the frame back to the minus pole of the battery, which is also earthed to the frame, thus completing the circuit.

When the engine is working, the cam E will, of course, be revolving, and the wedge at the end of T will rest on its circumference, except at the place where the notch occurs. Consequently, it will be seen that it is only when the wedge at the end of the trembler falls into this notch that contact will be made at the platinum points, and the circuit be completed. The vibrations of the trembler cause a series of rapid makes and breaks of the circuit which produces the spark in the combustion chamber as already described.

A non-trembler coil is used with this type of contact breaker.

The correct timing of the spark is effected by the proper inter-meshing of the cogwheels on the crank shaft, and the two-to-one shaft. This timing can, however, be altered to a limited extent by a method of swivelling the contact breaker, controlled by a rod running to a lever on the handle

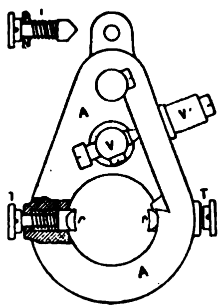


FIG. 10A.—LATEST DE DION CONTACT BREAKR

A, white metal plate; rr, ends of bolts engaging with a groove on a boss of the two-to-one gear case; TT, spring bolts fixing plate; V, platinum tipped screw and terminal insulated from plate but connected with terminal V^1; V^1, high tension wire terminal.

bar or steering pillar. Although the contact breaker can thus be moved through a certain radius, the position of the cam E remains the same in relation to the shaft B because it is fixed thereon, and consequently the time at which the projection on the trembler L falls into the notch of the cam can be varied, and the firing can be made earlier or later within certain limits.

In the latest type of De Dion car, this contact breaker has been altered. A metal block has taken the place of the fibre block, and the current is now earthed through the former, so that the only insulation used is in connection with the platinum pointed screw.

The type of contact breaker fitted to most motor bicycles has a positive make and break. The illustration shows the Minerva system, which is typical of all. The circle to the left of the diagram is a terminal with which is connected a wire from the plus pole of the battery. The current flows from this terminal through the screw I, which has platinum at one end. G is the so-called trembler, which in this case is merely a flexible spring, and does not tremble like the De Dion type. When the platinum point H comes in positive contact with the platinum on the screw I the circuit is completed, and the current flows through the trembler thence to earth, and so back to the minus pole, and at its break a spark is caused in the combustion chamber, as already described. With this type of contact breaker a trembler coil is used. The mechanism for bringing the point H in contact with the platinum on screw I is very similar to that of the De Dion, with this exception, that instead of a notch into which the hammer-shaped knob falls, a projection F on the cam D pushes the trembler G forward, until the two platinums come into contact. The cam D of

FIG. 11 A—SIDE VIEW OF WERNER ENGINE, SHOWING CONTACT BREAKER AND CARBURETTER

FIG. 11 B.—SIDE VIEW OF WERNER ENGINE SHOWING PULLEY AND CARBURETTER

course is a fixture to the two-to-one shaft E, and consequently revolves once for every two revolu-

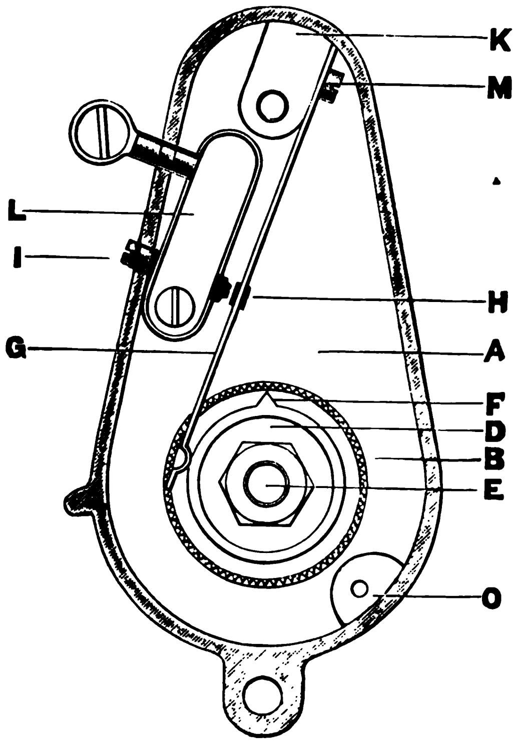


FIG. 11—THE MINERVA CONTACT BREAKER

tions of the flywheel. A is the pear-shaped case containing the mechanism, and inside it there is a sheet of mica, which lies between the plate L and

the case, so as to insulate it from the metal, and thus prevent the current from escaping before reaching the trembler.

The screw securing the plate L to the case is

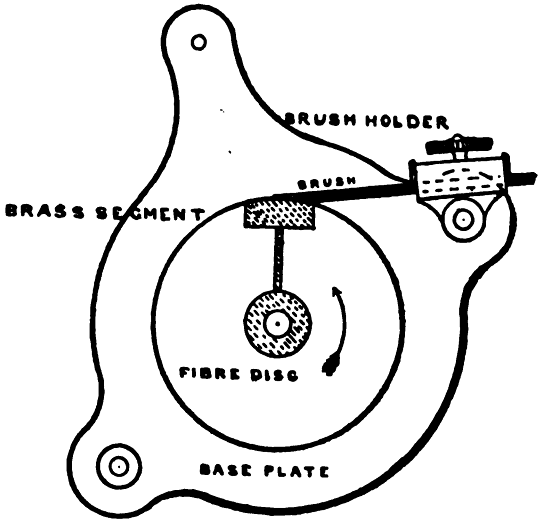


FIG. 12.—COMMUTATOR

also insulated, and, needless to say, it is very necessary to make sure that this mica is not cracked or broken, for if it is, a short circuit will occur.

The timing is accomplished in the same manner as in the case of the De Dion.

The commutator consists of a base plate, of insulating material, with a fibre disc, into which

FIG. 13.—THE DE DION-BOUTON SPARKING PLUG

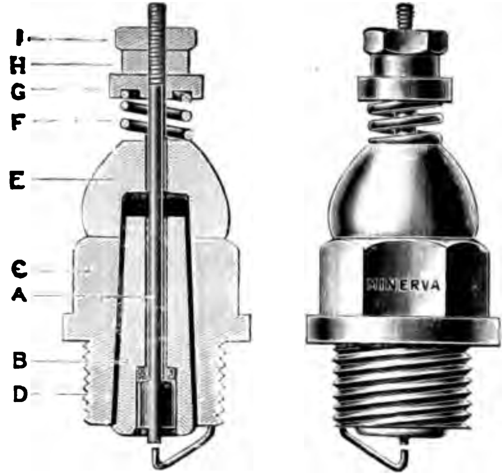


FIG. 13A.—THE MINERVA SPARKING PLUG

A. Central Conductor. B. Insulating Taper Centre.
C. Steel Case.
D. Thread to fit tapped hole in combustion chamber.
E. Supplementary Insulator.
F. Spring holding insulator to case.
G. Collar against which spring bears.
H. Lock nut. I. Binding nut

is let a brass segment. This segment is in metallic contact with the two-to-one shaft. The brush performs the same function as the trembler in the contact breaker. It is connected with one of the wires from the battery. As the fibre disc revolves in the direction of the arrow, the brass segment is brought in contact with the end of the brush, thus completing the electric circuit, for the current flows along the wire and thence to earth, from whence it returns to the battery. This system for breaking the electric circuit is often known as the "Wipe" system, because instead of making a positive make and break, or a trembling contact, the brass segment wipes against the end of the brush once in every two revolutions of the flywheel.

6. *The Sparking Plug.*—It is by means of a sparking plug that a spark is made to occur in the combustion chamber. Fig. 13 gives a good idea of its construction. The high tension current from the coil runs along the insulated wire, which may be seen forming connection with the top of the plug. Thence it follows the wire in the centre of the plug to the point A. At the break of the low tension current it jumps across the space between A and C, and thence back through the body of the plug and the frame of the car to the coil. It is the spark produced in the jump that fires the charge.

Having briefly described the various parts of the electric system, I shall now deal with the way it works. To begin with, it must be understood that to get a spark in the combustion chamber there must be two complete circuits, one of the low tension wire, and the other of the high ten-

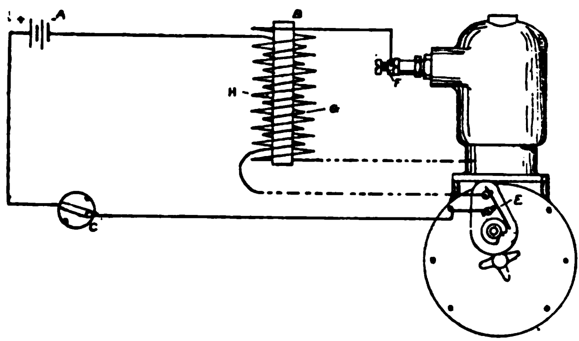


FIG. 14.—WIRING OF SINGLE CYLINDER ENGINE

sion. Fig. 14 illustrates the usual wiring of a single cylinder engine.

It will be noticed that a wire runs from the positive terminal of the battery marked + to the switch C, where the circuit can be broken at will. From C the wire continues to the contact breaker E, where, when the engine is running, the circuit is automatically broken and closed again, thus setting up an induced current. From the contact breaker E the current runs through the trembler to earth in the metal of the engine, and

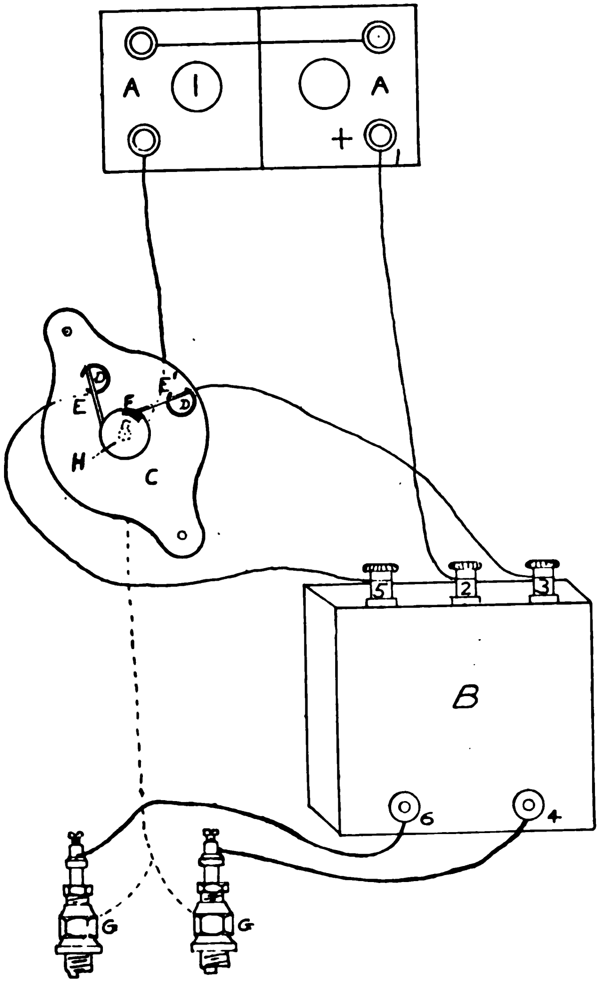


FIG. 15 —WIRING OF TWO-CYLINDER ENGINE

thence into the frame of the car, from which it is taken from any convenient point by an insulated wire to the coil B. After traversing the low-tension winding of the coil, it runs through another wire back to the negative pole, marked — of the battery, thus completing the low-tension circuit.

The alternate making and breaking of the low-tension circuit produces a high-tension current in the coil, which runs through the wire indicated by the line to the sparking-plug F, where, after jumping the gap between the points of the plug, and so causing a spark, it goes to earth in the engine and frame, and finally returns to the coil through the frame and a short length of wire as shown by the upper of the two dotted lines, thus completing the high-tension circuit.

The wiring of a two-cylinder engine is very similar, the principal difference being that instead of a contact breaker there is an accumulator with wipe-contact, and magnetic tremblers are fitted in the coil. In Fig. 15 the wiring is clearly shown. The current, as before, runs from the + pole of the battery, through the wire to terminal 2 on the double coil B. This terminal is connected with one end of the low-tension wire in each coil. It leaves the coil at terminal 3, and runs to the brush E^1, which, it will be noticed, is shown making contact with a segment of brass fixed in

the commutator disc H. Thence it goes to earth through the two-to-one shaft, and returns to the — terminal of the battery through the wire shown.

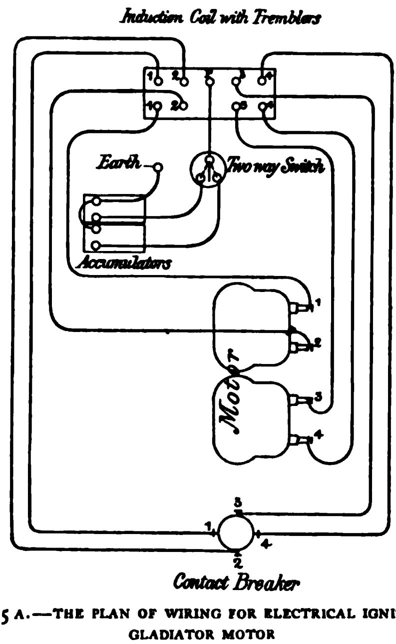


FIG. 15 A.—THE PLAN OF WIRING FOR ELECTRICAL IGNITION—GLADIATOR MOTOR

The high-tension circuit starts from the terminal 4, and runs to the sparking-plug of the right-hand cylinder, thence returning to the coil through the frame. This completes the two circuits for the right-hand cylinder. As regards the left-

hand cylinder, when the commutator—segment F — comes under the brush E, the current from the battery passes, as before, from terminal 2, and emerging from terminal 5, follows the wire to the brush E, and thence returns through earth to the coil. The high-tension circuit starts from the terminal 6, the current running through the wire to the left-hand plug, and from thence returning through earth to the coil. The dotted line shows both high-tension circuits returning to the base-plate of the commutator, which is part of the "earth." From this or some other part of the frame a wire—which is not shown in the diagram—takes the current back to the coil.

The same thing happens in a four-cylinder engine. There is a separate coil for each cylinder, and the commutator acts as an automatic switch, directing the current through the different coils in rotation.

(2) *By Means of a Dynamo*

The dynamo may be used either alone or in conjunction with storage cells, but the latter system is not common.

(3) *Magneto-Ignition*

One of the simplest in its working, yet most mysterious in its principles, is that of magneto-

ignition. The electric energy is produced, not from chemicals, but by the conversion of mechanical energy.

Somewhat similar to the action of the magneto machine is the dynamo, but there is an important difference nevertheless. In the dynamo the poles are of soft iron, which only become magnetised when a current of electricity is passed round them. In the magneto machine the magnets are permanent, and are made of steel. Lines of magnetic force flow between the poles, and they can be so acted upon as to give rise to an electric current.

The magneto machine usually has three magnets of horseshoe shape. Between them is the armature in which the induced current is set up. In the Simms-Bosch magneto machine, which is one of the best known in connection with motor work, the armature is fixed, and lies between the pole pieces of the magnets, an air-space separating them.

An iron shield in two sections is caused to revolve between the pole pieces and the armature, and this in its motion gives the lines of force varying directions, and by this disturbance sets up an electric current in the armature.

When the shield lies between the armature and the pole pieces, the lines flow horizontally from pole to pole through the shield and the armature. Now, if the shield be moved so that

it lies above and below the armature instead of at the sides, the lines will be diverted, for instead of crossing in a horizontal line through the armature, they will take two circular paths to follow the shield, as the air-space offers more resistance. The illustrations will show the alternate paths taken.

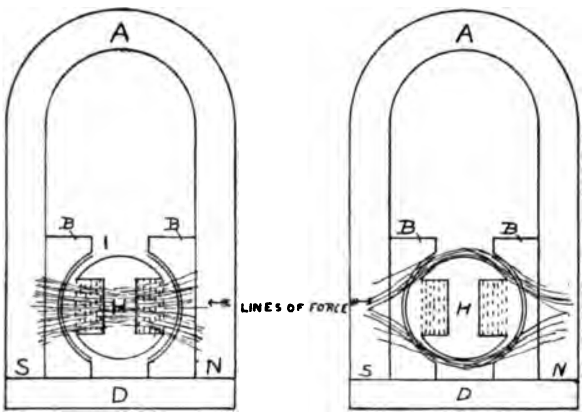


FIG. 16. FIG. 17.

SIMMS-BOSCH MAGNETO MACHINE

A is one of the magnets viewed from the side; B is the pole piece; H the armature which is of iron, wound round with insulated wire, one end being earthed, and the other running to the sparking plug. N and S show the north and south poles respectively of the magnet; I is the iron shield which is caused to revolve by the motor.

In fig. 16 the shield is shown between the pole

pieces and the armature, and the magnetic lines therefore flow horizontally. In fig. 17 the shield is above and below the armature, and the lines seeking the paths of least resistance take semicircular courses. Now, if the shield be rapidly revolved it will cause alternate flowing of the lines through and away from the armature and an induced current will be set up therein.

From this it runs to the sparking plug and completes the circuit by running back through the earthed wire. It must be borne in mind that a current flows only during the revolution of the shield, and that the mechanical work done in turning it is the equivalent of the electric energy obtained. When the shield is stationary no current is induced.

The current obtained from the magneto machine is of the low tension variety, and is not powerful enough to jump across the gap in the ordinary sparking plug. A special system of firing is therefore adopted. The current is led up to an apparatus within the cylinder where it is at a certain moment broken by a mechanical contrivance. One part of the plug is caused to quickly move away from the other, and at this break of contact a spark passes which ignites the explosive mixture.

Fig. 18 gives a general view of the Simms-Bosch ignition. The shield is numbered 20 at both sides of the armature. 20 is caused to oscillate

by the rod 63. The induced current flows by the wire 26 to the sparking apparatus 27 mounted on the combustion chamber. The plug is in the form

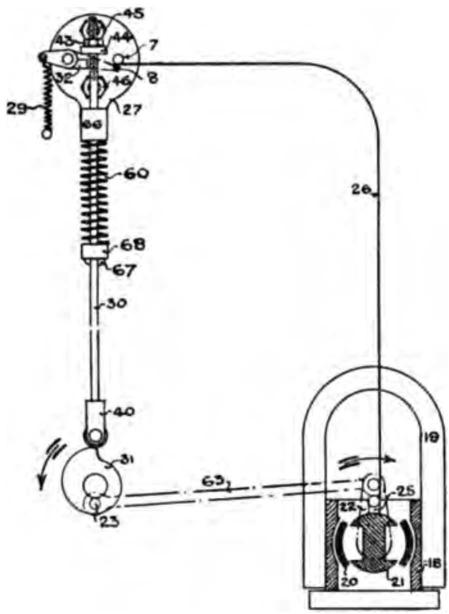


FIG. 18.—GENERAL VIEW OF THE SIMMS-BOSCH IGNITION

of a flange with a boss inside and outside, through which pass the insulated pin 7 and the spindle of the oscillating lever 8. This lever is held against the pin by the small spring 29, so that when in contact there is a complete circuit. 7 and 8 are

placed within the combustion chamber, and are made a gas tight fit.

When a spark is to be produced, the ignition cam 31 revolves until the trip rod 30 drops down. As a result the tappet 44 descends and strikes the external lever 32, and thus it makes the interrupter lever 8 break contact sharply with the insulated pin 7. A spark occurs at this instant, and the cam maintaining its motion brings back the interrupter 8 to contact with 7, and so closes the circuit again.

It must be understood that whereas the interrupter lever 8 is inside the combustion chamber the lever 32 is outside.

An ingenious arrangement is fitted whereby the time of firing can be altered to suit the pace of the engine.

(4) *Tube Ignition*

This system of ignition is now only fitted in conjunction with electric ignition, as a stand-by in case of derangement of the latter. A platinum tube closed at one end projects into the cylinder head. A small passage from the combustion chamber leads into the tube, and when the gas is compressed, it is forced into the tube. A Bunsen burner, supplied with petrol, is arranged under the tube. This burner maintains the tube at a bright red heat, so that when the gas is forced underneath it ignition takes place.

DE DION-BOUTON 8-H.P., 1903, MODEL LIGHT CAR. DOUBLE PHÆTON CARRIAGE BODY, WITH CANOPY

[redacted]

Needless to say, the tube ignition cannot be advanced or retarded, as with electric ignition, but it can be set to ignite the charge at a predetermined moment, according to the speed at which the engine is set to run. This is accomplished by varying the opening into the combustion chamber with a nipple which alters the period of time taken for the flame to reach the body of gas in the cylinder, after it has been ignited in the tube. Tube ignition is very reliable, but rather dangerous in consequence of the naked flame from the Bunsen burner.

THE CARBURETTER

The carburetter is the chamber in which the spirit of petroleum—commonly called petrol—is vaporized and mixed with air in the proper proportions to form an explosive mixture. The name is, however, generally used to include the entire apparatus connected therewith.

Carburetters are of two types, surface and spray. The former is used mainly for cycle engines, and depends for its efficiency on air passing over a large surface of petrol contained in a chamber and so becoming heavily charged with the vapour. The illustration gives an idea of the principle. AAAA is a metal tank which is made in various shapes to suit different designs. The petrol, as will be seen, rests at the bottom of the tank. B is a tube which is a tight sliding fit

in a collar on the top of the tank, and to the bottom of this tube a plate sometimes is fixed, its object being to cause the air drawn in through the tube B to spread over the surface of the petrol. E is a float, which indicates the height of the petrol by means of the wire which protrudes

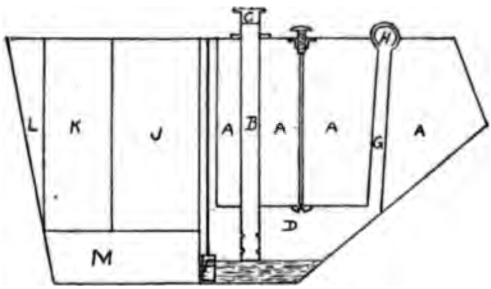


FIG. 19.—SURFACE CARBURETTER

through the top of the tank. The crude vapour and air ascend together to the tube G, and so reach the mixing chamber H. In this chamber there is a double-acting valve; one lever regulates the proportion of air and vapour, and the other regulates the quantity of mixture passing to the engine.

The spray type of carburetter is used on the great majority of cars, and is beginning to supersede the surface carburetter even in the case of cycle engines. The illustration shows the latest type fitted to the Daimler cars. The petrol ascends through the pipe U I into the float cham-

ber U 3. Above this chamber rests the float, which rises and falls with the petrol. As it rises it presses on the hinged arms attached to the spindle running through the float. The end of this spindle is conical-shaped, and acts as a valve

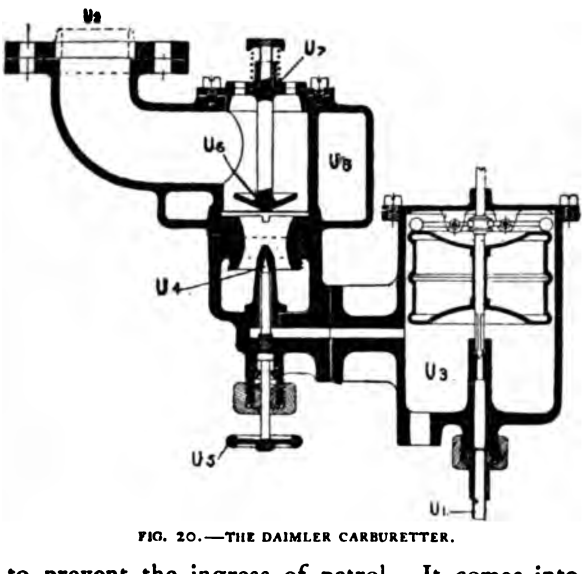


FIG. 20.—THE DAIMLER CARBURETTER.

to prevent the ingress of petrol. It comes into action when the float rises to such a height that the arms press the spindle down until the conical end of the valve gets home on its seating. From the float chamber the petrol is sucked by the engine up a long horizontal passage to the jet U 4. It spreads out through the jet and strikes

the conical spreader U 6. The air ascending from the bottom of the carburetter mixes with the atomized petrol as it comes from the spreader, and the mixture thus formed is drawn into the pipe U 2, and so into the combustion chamber. U 7 is an adjustable supplementary air inlet, in case sudden changes in temperature necessitate a variation in the mixture. The hand wheel U 5 is for the adjustment of the needle valve. A drain-cock is fitted beside the pipe U 1 for letting off the petrol as desired, and clearing out the bottom of the carburetter.

Carburetters are generally adjusted for a normal engine speed, and consequently as this speed drops, the suction is not sufficient to draw sufficient petrol through the spraying jet, in proportion to the amount of air, which enters through the upper, or supplementary air inlet. Consequently, the mixture becomes attenuated, and when the speed of the engine drops to a certain point, is no longer explosive. It is mainly for this reason that when the engine is running idle, and the car standing still, the noise is so great, for the speed cannot be reduced sufficiently owing to the vitiating of the mixture. In some of the latest types of carburetters, this difficulty has been got over by regulating the supplementary air inlet, so that when the pace falls, it is gradually closed. Consequently the air is wholly, or almost wholly, drawn from the lower inlet, and rushes past the

spraying jet, drawing with it the greatest possible amount of petrol. In the case of the Napier, the carburetter is normally set to give a correct mixture at the lowest speed, and as the pace increases the supply of air is also increased.

THE GOVERNOR

The object of the governor is to regulate the speed of the engine in relation to the work done. It will be easily understood that where the variation in the work to be done is so great, some means must be provided to keep the speed of the engine reasonably constant, for, needless to say, if there were no method of control, and a heavy load were suddenly removed from the engine, it would race; or if the engine were running at a slow pace, and a steep hill were encountered, it would probably stop.

The speed of the engine is calculated by the number of revolutions of the flywheel per minute, and there is very great variation indeed in different engines. The speed varies from a normal speed of about 700 revolutions to about 1500, but a considerable variation can be obtained by operating the governing devices. Small single-cylinder engines are made to run at a greater pace than the large engines fitted to big cars. Until recently, the impression was general that these small engines running at a high speed would quickly knock themselves to pieces. Practice, however,

has not borne out theory in this respect, and the small high-speed engines have done so well that many makers have greatly increased the speed of the engines used in the large cars. This enables them to get higher h.p. without increasing the weight.

Governing by Ignition.—This was the earliest and simplest system adopted, and consists in regulating the time at which the spark occurs in the combustion chamber. It is still relied upon in the case of the small single-cylinder engines. It will easily be understood that to get the best result, the charge should be exploded at the moment when the piston is at its highest point, just as when pedalling a bicycle, the pressure should be applied the instant the pedal passes the dead centre. When the spark is thus timed, the engine will run at its highest speed. If, however, a slower speed is desired in proportion to the work to be done, the spark should be retarded so that the explosion takes place after the piston has begun to descend. This naturally makes a weaker explosion, and so causes the engine to run at a slower pace.

In many cases a hand throttle is fitted in connection with this system of governing. By means of this throttle, the operator can regulate the quantity of mixture passing to the combustion chamber, and so can control the speed of the engine to a certain extent, independently of the

sparking. When the hand throttle is fitted, the driver should aim at using the least amount of mixture compatible with the work to be done, and exploding it at the best possible time. In other words, he should invariably explode his mixture when the piston is at its highest point, and should regulate the power of the explosion, and consequently the pace of the engine, by means of the quantity of mixture which he allows to pass to the combustion chamber. Needless to say, this requires great skill and experience, and it is partly for this reason that mechanically operated governors have come into general use.

Governing by means of a Valve-lifter.—The valve-lifter is really a device for keeping the exhaust valve held up. This prevents the piston from exerting sufficient suction to open the induction valve, and so no fresh charge is taken in. It is used mainly on cycles for starting purposes, to enable the rider to pedal easily in traffic when his engine is not running, or if the motor breaks down; and for cooling the engine when running free down-hill. It can be utilised, however, for governing also if the adjustment is so nice that the lift can be regulated so that the valve will only remain very slightly open. This only reduces the suction caused by the piston to a limited extent, and consequently a reduced charge enters through the inlet valve, giving in turn a reduced explosion.

When worked from the handle bar, it is an exceedingly efficient and simple method of governing these small engines.

Governing by means of Valve-closer.—This arrange-

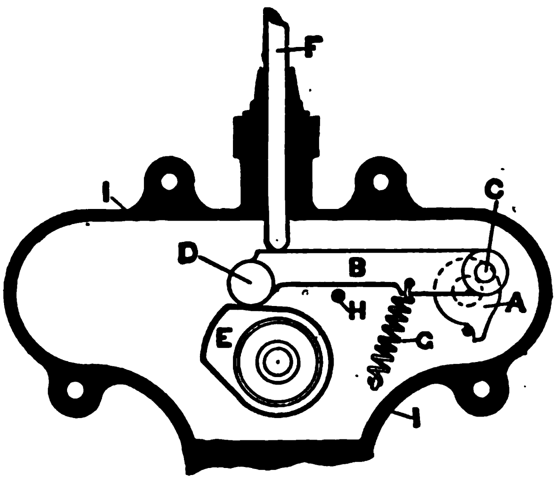


FIG. 21.—EXHAUST VALVE REGULATOR

is used in the De Dion car. It has the advantage of regulating the quantity of gas admitted, without diminishing the compression. In the old style, when a small quantity of gas was admitted to the cylinder, it had to occupy the same space as a full charge, and thus lost compression. Now the exhaust valve being closed to a certain extent does not allow all the exhaust gas to escape, and

this prevents a full charge of fresh gas being drawn in through the inlet valve.

The cam E acts on a rocker B pivotted eccentrically on to a disc A, which is moved by a lever controlled by the pedal or the hand lever. Normally, the eccentric is so placed that the rocker B is at its highest point, and thus at each stroke of the cam the exhaust valve is opened to its fullest.

If the disc A is revolved from right to left the rocker B is pushed forward so that the cam E reaches the roller D at a later point in its revolution; therefore a lesser lift is given to the plunger F. The illustration shows the cam E leaving the roller D. According to the amount of motion given to A the lift of the exhaust valve is regulated. H is a stop on which rocker B rests when at its lowest. G is a spring which maintains B in position.

By Governing the Throttle Mechanically.—This is the system in most general use in large cars. Briefly put, it consists in regulating the quantity of mixture admitted to the combustion chamber by means of a mechanically operated governor. A simple experiment will enable the reader to grasp the system on which this governor acts. If he attaches a weight to a piece of string, and holding the end in one hand revolves that hand rapidly in a circle, the centrifugal force will make the weight fly outward, and as the speed at which

he moves his hand round increases, the weight will gradually rise until the string will form a right angle to the perpendicular.

The diagram will explain the method of adapting this principle to the motor. B is a gear wheel attached to the two-to-one shaft, and may be

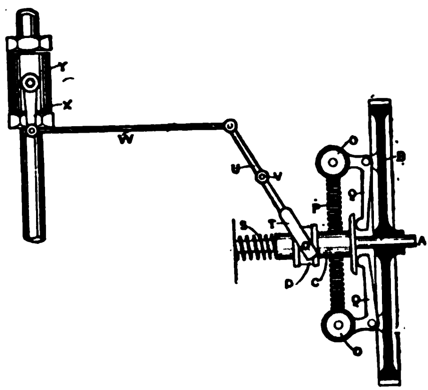


FIG. 22.—THROTTLE GOVERNORS

taken as occupying the position of the hand in the experiment already described. OO are two weights attached to B close to the circumference, and C is a coil spring which tends to pull these weights towards each other. Now it will be easily understood that when the gear wheel B is revolved rapidly by the two-to-one shaft A, that the weights fly outwards, and as they separate the arms QQ are pushed forward and bear

against the sleeve C. C is free to slide on the shaft A, and as it is pushed forward, operates the fork T and rod U, which is pivotted at V. The throttle is contained within the chamber Y, and is worked by the lever X. It will be easily seen, therefore, that as the sleeve C works backwards and forwards under the influence of the governor arms on the one side, and the spring S on the other, that the lever X will be operated, and so will work the valve in the chamber Y which controls the amount of mixture passing to the combustion chamber, and so regulates the speed of the engine. The throttle chamber Y is generally situated close to the carburetter, or between the carburetter and the induction pipe.

By Mechanically Governing the Exhaust Valve.—This is a system which was in very general use until recently. The same sort of governor is fitted, but instead of operating on the throttle, it prevents one or more exhaust valves from opening when the speed of the engine reaches a certain point, so that one or more of the combustion chambers remain full of the products of combustion, and no fresh charge can be admitted. As a result, the speed of the engine will slacken until the valve or valves, which are temporarily prevented from opening, are allowed once more to act, and fresh charges are admitted to the combustion chamber or chambers. The *modus operandi* is really very simple. The action of the governor

on the sliding-sleeve C has the effect of making one or more of the plungers which lift the exhaust valves miss the end of the valve-spindles, commonly referred to as the diggers. Consequently the valve is not lifted, and the products of combustion remain in the combustion chamber, and prevent a fresh charge from getting in.

Governing by Hand Throttle and Mechanically-operated Exhaust Valves.—This is really a combination of both the last-named systems. The exhaust-valves are governed as already described, and at the same time the quantity of mixture reaching the combustion chamber is regulated by means of a hand-worked throttle valve. By the skilful use of this throttle valve, the exhaust valves may be almost entirely prevented from cutting out. Needless to say, its proper manipulation requires some skill, but when thoroughly understood the combined system is most effective.

WATER CIRCULATION

In most cars the engine is cooled by means of water which runs from a tank to the water-jacket of the engine, thence to the radiators, where it is cooled, and returns again to the tank. There are two systems in use. In one, pumps, generally of the rotary or semi-rotary pattern, force the water into the water-jacket of the engine, and drive it through the radiators and back to the tank. The other system is known as the "Thermo-Syphon."

DE DION-BOUTON 6 H.P., 1903, MODEL VOITURETTE VICTORIA CARRIAGE BODY WITH SPIDER SEAT

[redacted]

In this system the tank is situated higher than the engine, and the water consequently flows by gravity into the water-jacket. As it gets heated, it rises naturally back to the tank, passing on its way through the radiators. In some cases the two

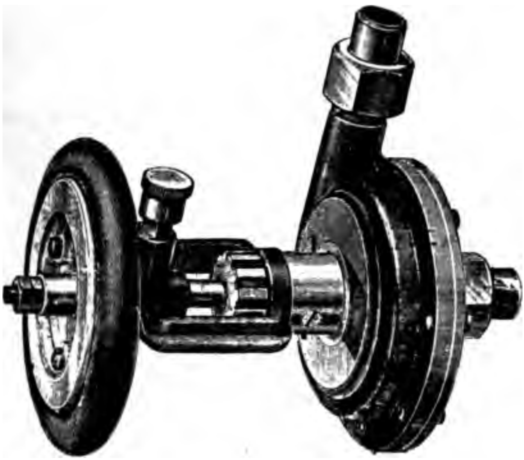


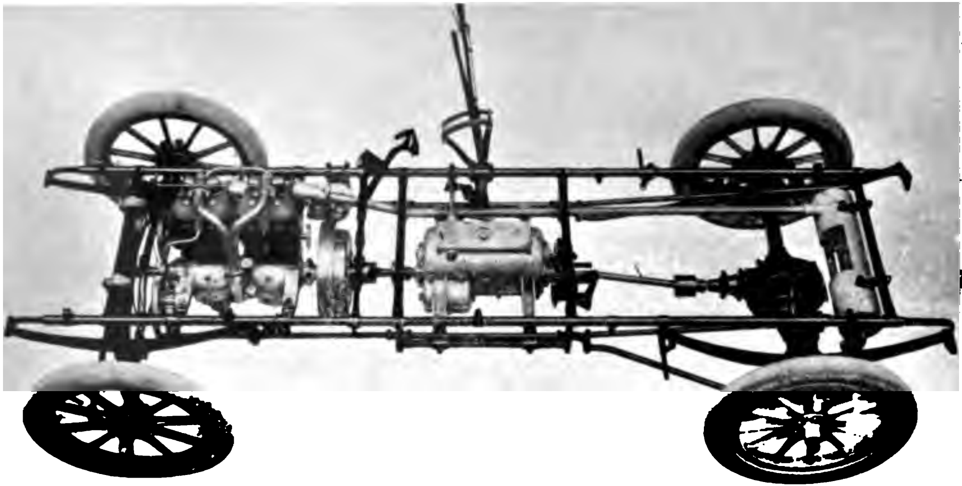
FIG. 23.—CENTRIFUGAL PUMP

systems are practically combined, the tank being so placed that if trouble should occur with the pump, the water will circulate naturally.

The centrifugal pump requires a high speed of about 2000 revolutions, but with a semi-rotary pump from 300 to 400 revolutions is sufficient. In the centrifugal a fan-wheel revolves in an enclosed chamber, and consequently there is, prac-

tically speaking, nothing to get out of ord
From this point of view this pump is superior
the semi-rotary, but the high speed is trying c
the bearings. In the semi-rotary pump there ar
four valves, which sometimes give trouble; dir
or grit will prevent them closing, and at time
they need adjustment. They are also apt to becom
worn and to need reseating, or may even requir
new fibre or rubber washers.

We shall deal with this subject again in a sub
sequent chapter.



CHASSIS OF FOUR-CYLINDER 12-H.P. VELOX CAR

[redacted]

Change Gear and Transmission

IT is by means of the change gear and transmission that the power of the engine is transferred to the road-wheels, and both are so intimately connected with each other that we shall describe them together. We shall first deal with the various parts in detail, and then take a typical car and describe the whole as one.

THE CLUTCH

The object of the clutch is to connect two shafts in the same plane so as to run independently of each other or together. The clutch is usually interposed between the revolving engine-shaft and the transmission gear. The connection can be broken at any time by the driver, so that the power ceases to be communicated to the road-wheels. The friction clutch is the one most generally in use, and as a rule forms portion of the flywheel. It is depicted in fig. 25. A is the flywheel which revolves with the engine shaft, and the concave portion of which forms the female part of the clutch. B is the male portion, and when it is in contact with A the drive is continuous through the engine shaft, flywheel, gear shaft and gear to the road wheels. It can be slided along the gear shaft, and is held

up to its work by a strong spring. The action of a foot pedal draws it out of contact, when of

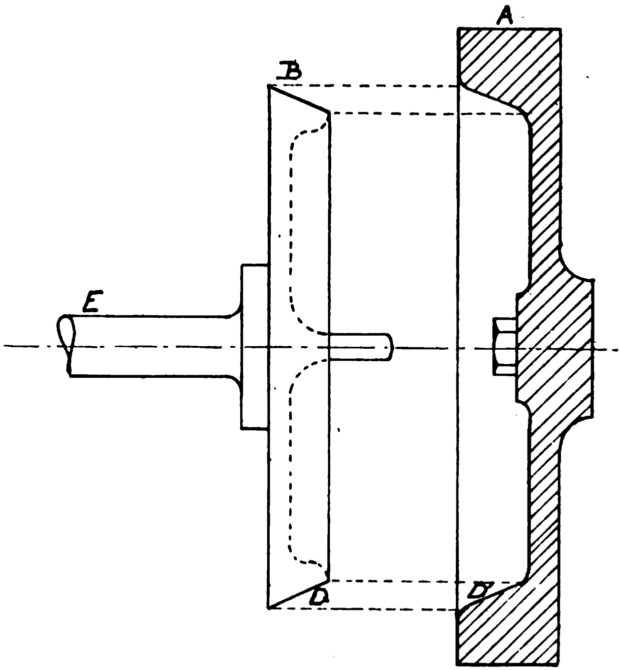


FIG. 24.—SINGLE CLUTCH

course the engine simply revolves the flywheel without actuating the gear. One of the principal objects of the friction clutch is to enable the car to be started without shock or jar. For example, if the clutch is withdrawn, and the engine work-

ELEVATION OF CHASSIS OF FOUR-CYLINDER 12-H.P. VELOX CAR

[redacted]

ing, the flywheel will revolve at a great speed. If the clutch were suddenly let into contact the strain would be enormous, and would probably not only stop the engine, but damage the mechanism. By letting it in slowly and gradually, however, the female portion B slips on the male

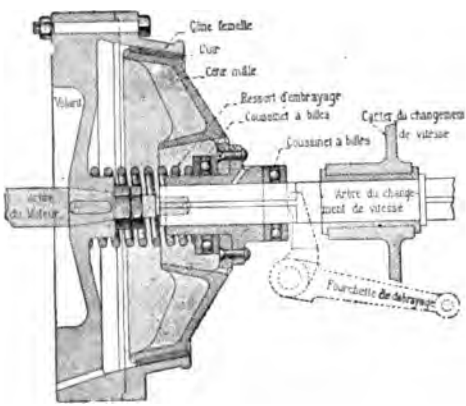


FIG. 25.—THE CLUTCH—GLADIATOR LIGHT MOTOR CARRIAGE

portion A, and consequently there is no jar, and the car starts off slowly and smoothly.

This type of clutch is used on most of the cars at present on the market.

The expanding clutch is another variety of the friction clutch. It is illustrated in fig. 26. Within the recess formed by A are two segments, CC, which are leather-faced, or covered with red fibre or ground true at D. These segments are made

to expand and contract by actuating a lever and pedal. The segments are usually connected to a sleeve, E, which, when actuated by levers, slides upon the gear shaft. A spring normally keeps the segments in contact with the flywheel, when of course the drive is continuous. When C is

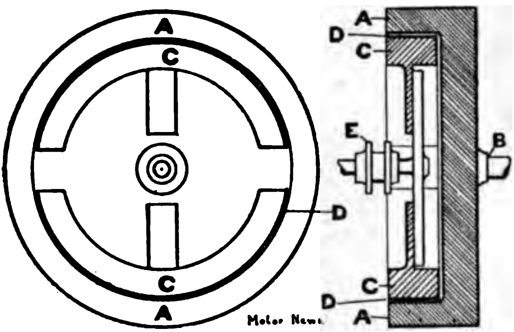


FIG. 26.—THE EXPANDING CLUTCH

removed from contact with A by means of the levers, the engine runs free. In order to start slowly, C is gradually let into contact with D, and, as in the case of the clutch already described, the contact is first of a slipping nature, so that the power is taken up by degrees. The well-known De Dion clutch, which is of this type, is situated inside the pinions.

THE GEAR

And now we come to the gear, which is actuated through the clutch and gear shaft.

Change Gear and Transmission

The object of the gear is to compensate for the fact that the petrol engine is not elastic, but gives its maximum power at a certain number of revolutions per minute. Consequently, in order to get sufficient power for hill-climbing a reduction gear has to be fitted. There are two systems most generally in use.

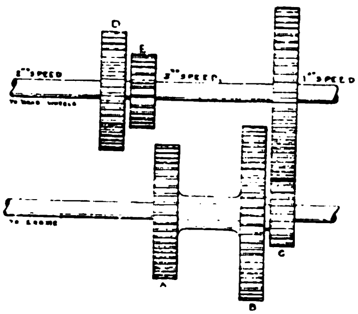


FIG. 27.—DAIMLER THREE-SPEED GEAR

Fig. 27 shows a three-speed gear on the lines adopted on the Daimler, Panhard, and other well-known cars. It consists of a double series of tooth gear wheels of different diameters, which are mounted on two parallel shafts. The shaft on which the pinions A, B and C are mounted are connected with the engine by means of the clutch, while the other shaft transmits the power to the countershaft of the car and thence to the road wheels. In the case of a central drive, however, a jointed shaft runs longitudinally from the

gear case down the car to a big bevel wheel on the rear axle. The wheels A B and C are fixed on a sleeve which slides on the shaft, and consequently by means of levers pinion C can be brought into mesh with pinion F, as in the diagram, thus giving the lower speed. Pinion A can be brought into contact with pinion D, giving the second speed, and pinion B into contact with

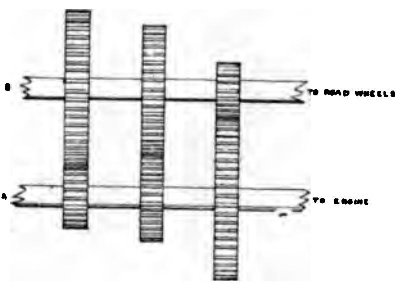


FIG. 28.—THREE-SPEED GEAR

pinion E to give the highest speed. We might mention that on most big cars there are four speeds, which necessitate an extra pinion on each shaft.

In the other system, depicted in fig. 28, the gear wheels are always in mesh, but only one pair are doing work at the same time. The others remain idle. A sliding key or clutch throws them in and out of operation, according to the gear which is required, or in some systems an expanding clutch is used. The reverse is, as a rule,

effected by means of an idle pinion, which it is impossible to show clearly in the diagrams.

As already mentioned, there are two forms of transmission, In the system adopted in the Napier, Panhard, and such-like cars, the secondary gear shaft drives on to a countershaft which is arranged across the car, by means of bevel wheels. On

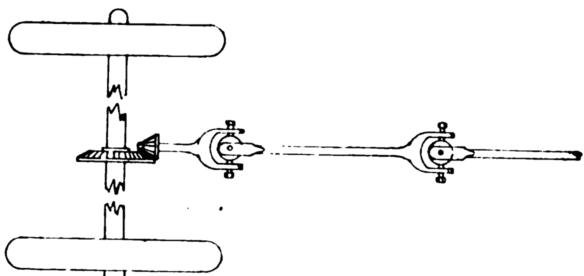


FIG. 29.—ARBOR SHAFT

the extreme end of the countershaft are mounted sprocket wheels. Similar sprocket wheels are fixed on the hind wheel axle, and chains transmit the power between the two.

In the other system the drive is taken from the central shaft running direct from the gear box to a large bevel wheel on the centre of the rear axle. This is usually referred to as an Arbor or Cardan shaft, and has universal joints, enabling it to give in any required direction, to allow for the variation between the position of the gear box and rear axle, due to the road vibration. It is a

simple type of transmission, extensively used in small cars. The strain on the large bevel wheel is very great, and unless made specially strong to stand it, trouble will result.

THE DE DION SYSTEM

The De Dion system affords an excellent example of the expanding clutch. The engraving, fig. 31, gives a good idea of its general construction. The main shaft, I, is connected to the engine shaft by means of what is commonly known as a Cardan or Arbor shaft, that is a shaft with universal joints. F is a pinion which runs loosely on this shaft, and G is another pinion which is fixed to the shaft. Between these two is a sliding sleeve M, carrying a small pinion H. Although this pinion slides freely along shaft I, it is secured thereto by three feathers, so as to be made to revolve with it. By means of a striking fork, which is worked from the steering pillar, this sleeve and pinion can be moved either to right or left. K is a hollow countershaft, which contains at one end a bevel pinion gearing with a large bevel pinion on the driving axle of the car, and so communicating the power to the road wheels. E is a pinion secured to the clutch box A. Inside clutch-boxes A and B are expanding clutches operated by a lever on the steering column and a ratchet inside the hollow shaft K. When the clutch inside B is expanded, the pinion D is

FIG. 30.—THE GLADIATOR FOUR-SPEED GEARING

FIG. 31.—GENERAL ARRANGEMENT OF THE DE DION THREE-SPEED GEAR AND REVERSE

The reversing pinion is seen in the gear-box to the right. The middle gear is in operation

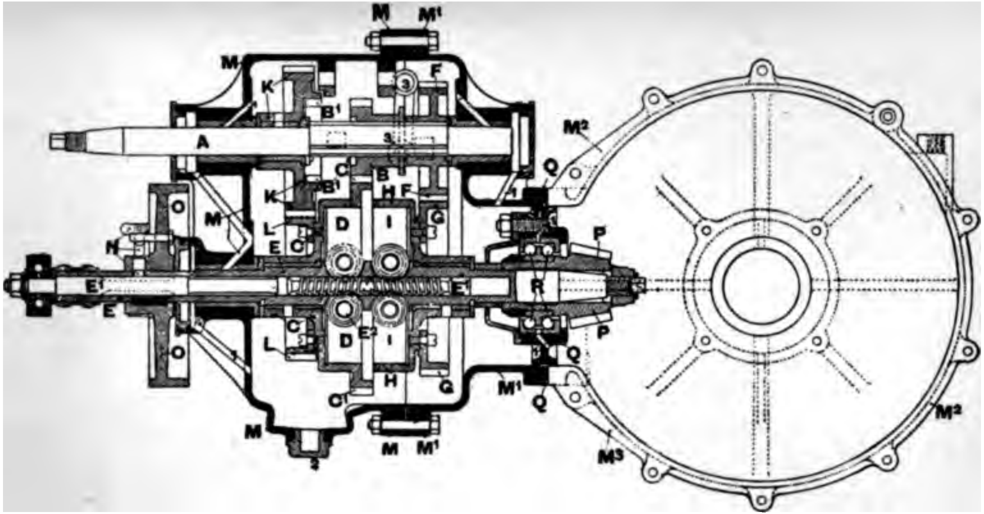


FIG. 31 A.—LONGITUDINAL VERTICAL SECTION OF THE DE DION THREE-SPEED GEAR

thereby connected with the shaft K, while the same action takes the clutch inside A out of operation. When in turn the clutch inside A is operated by the movement of the same lever, the pinions C and E become one with the shaft K, and the clutch inside B is withdrawn.

When the operating lever occupies the central position, neither clutch is in operation, and therefore all three pinions, C, E and D, run free on the shaft K. Consequently when the clutch is in this position the engine drives free.

Now, the different gears are arrived at in the following manner. When the first speed or low speed is required, a small lever on the steering standard is operated so as to make pinion H mesh with pinion E, and the gear change lever is then operated so as to expand the clutch inside A. The drive is then communicated from the engine through the medium of shaft I, pinion H, pinion E, and the bevel pinion on the end of shaft K to the large bevel wheel on the road wheel axles, thus giving the low speed.

When the second or medium speed is required, pinion H may occupy the position depicted in the engraving, or else may be left in mesh with pinion E, it matters not which. The gear is put into operation by expanding the clutch inside clutch box B. Pinion D becomes fixed thereby to the shaft K, and is driven through the medium of I and G, thus transmitting the power to the road

wheels by means of the bevel pinions already alluded to.

And now for the high speed. It will be borne in mind that pinion F runs loose on shaft I, that pinion H is secured thereto by means of feathers on which it slides, and that pinion C is free on shaft K, until the clutch inside gear box A is actuated.

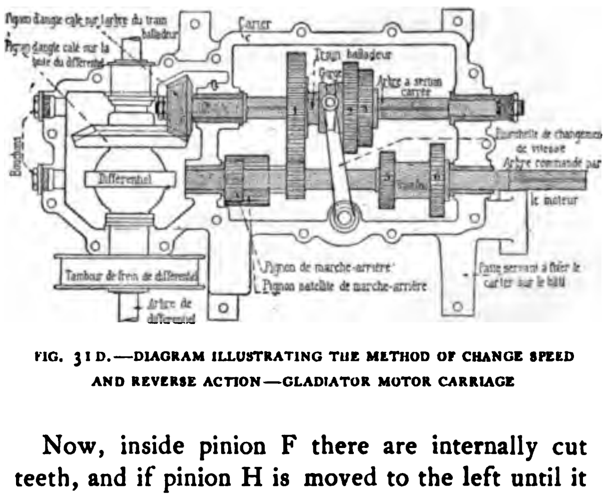


FIG. 31 D.—DIAGRAM ILLUSTRATING THE METHOD OF CHANGE SPEED AND REVERSE ACTION—GLADIATOR MOTOR CARRIAGE

Now, inside pinion F there are internally cut teeth, and if pinion H is moved to the left until it meshes with these teeth, it becomes a positive clutch, and grips pinion F to the shaft I. Consequently when the motor is at work pinion F revolves pinion C. If now the clutch lever is operated so as to expand the clutch inside gear box A, pinion C is thereby fixed to shaft K, and so the power is transmitted through I, F, C and K

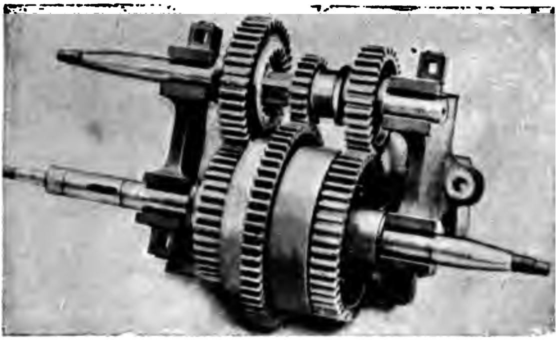


FIG. 31 B.—DE DION THREE-SPEED GEAR

The position of the gear on the slow speed. Note the internal teeth on the left wheel on the top shaft

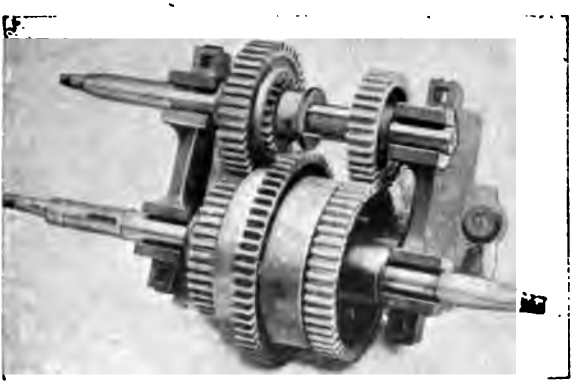


FIG 31 C.—DE DION THREE-SPEED GEAR

The high speed in operation. The slow speed pinion is entered into the left wheel on the top shaft

to the bevel pinions already alluded to, thus obtaining the third or high speed.

The reverse is accomplished in an exceedingly clever manner. The clutch lever is moved to the middle position, so that neither of the clutches in the clutch boxes are expanded. The small lever which controls sleeve M and its pinion H is then operated so as to bring H into the position which it occupies in the engraving.

Now, if the reader will look at the drawing of half the inside of the gear case at the right hand side, he will see a pinion L. This pinion is twice as broad as either B or H, and by the movement of the reverse lever can be brought into mesh with both. If the clutch inside clutch box A is then expanded, the shaft K is rotated in an opposite direction to that in which it has previously been driven, and by this means the car is driven backwards.

The following key to the lettering of fig. 31 A should make that diagram clear :—

A, mainshaft rotating at the same speed as engineshaft. B, sliding sleeve toothed pinion shown engaged with toothed ring C1 C1 on countershaft, clutch box CC giving first or low speed. B1 B1, internally toothed ring part of toothed wheel KK. CC, third (high), first (low), and reverse speed clutch box. C1 C1, toothed ring on clutch box CC. DD, expanding clutch conveying drive from clutch box CC to countershaft EE. EE, hollow countershaft.

E 1 E 1, change speed rack within the hollow countershaft, and serving by in and out rectilineal movement to expand and withdraw clutches DD II in a manner so that when DD is expanded II is withdrawn, and *vice versâ*. FF, toothed pinion fast on mainshaft A, and meshing with toothed ring GG on clutch box HH giving second speed. HH, second speed clutch box. II, expanding clutch conveying drive from clutch box HH to countershaft EE. KK, toothed wheel loose on mainshaft A, but when clutched to same by introduction of sliding pinion B into teeth of internally toothed ring on toothed wheel KK serves to convey drive from mainshaft A to clutch box CC through toothed ring LL on clutch box. LL, toothed ring bolted to clutch box CC, and forming with B 1, B and KK the third or high speed train. MMM, forward portion of gear box. M 1 M 1 M 1, rear portion of gear box. M 2 M 2 M 2, differential gear case. N, plunger bolt to prevent change speed rack E 1 turning in countershaft. PP, bevel pinion on end of countershaft EE; driving bevel wheel on differential gear box, not shown. QQ, disc carrying double ball bearing. R, double ball bearing carrying tail end of countershaft EE. 1 1 1 1, lubricating oil channels.

There is a third method of change gear, once largely used, but now almost discarded. It is accomplished by means of belts running on different sized pulleys.

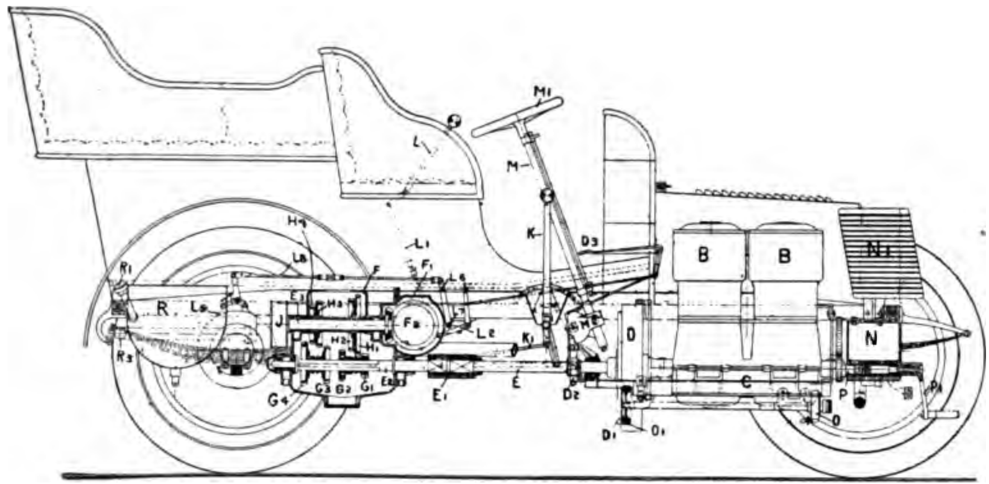


FIG. 32.—SIDE ELEVATION OF 22-H.P. DAIMLER CAR

[redacted]

The Complete Car

AND now having described in detail the different vital parts of a motor, I shall proceed to point out how these are combined so as to produce a perfect car, and will select as a typical specimen the latest pattern of 22-h.p. Daimler.

Fig. 32 shows a side elevation of this car. BB represents two of the four cylinders, and C the crank chamber. The motor shaft may be observed projecting rearward from the crank chamber. On to this is fixed the flywheel D. The shell of this fly-wheel forms the female portion of the clutch, and D 1 is the male portion. This male portion is fixed on to the clutch shaft E, which in turn is secured to the primary gear shaft by means of a flexible coupling E 1. This flexible coupling allows shaft E to slide longitudinally, carrying with it of course the male portion D 1 of the clutch. Now, a strong spiral spring (not shown in the engraving) acts on the fork D 2, and so keeps the male portion of the clutch D 1 up to its work. When, however, the pedal D 3 is operated with the foot, a lever overcomes this action of the spring, and forces the shaft E backwards through the sleeve E 1, carrying with it the male portion of the clutch D 1. It will there-

fore be seen that when the male portion of the clutch D 1 is in engagement with D, the engine will drive through shaft E, primary gear shaft E 2, and secondary gear shaft E 3. Now, on the forward end of shaft E 3 there is fixed a small bevel pinion, which meshes with a large bevel pinion, which in turn is fixed on to the main countershaft, which crosses the car laterally. If our readers will turn to fig. 32 B, which shows a plan of a 12-h.p. chassis, they will there see this countershaft plainly shown; it is marked F 2. This countershaft is revolved through the medium of the bevel pinions. On the end of the countershaft are chain wheels, commonly called sprockets, and marked F 3, which are in turn connected by heavy chains to large sprockets on the rear wheel axle. It is through the medium of these chains and sprockets that the power is finally conveyed to the road wheels.

When the driver wishes to disconnect his engine, so that the power is no longer transmitted to the road wheels, he has only got to depress foot pedal D 3, which withdraws the male portion of the clutch D 1, and leaves the flywheel D to revolve idly.

The operation of the change-speed mechanism can be easily followed in fig. 32. The pinions G 1 and G 2 are fixed to a sleeve which slides on the primary gear shaft E 2 when actuated by a lever. G 3 and G 4 are similarly fixed to a sleeve which is operated in the same way. On the upper

3

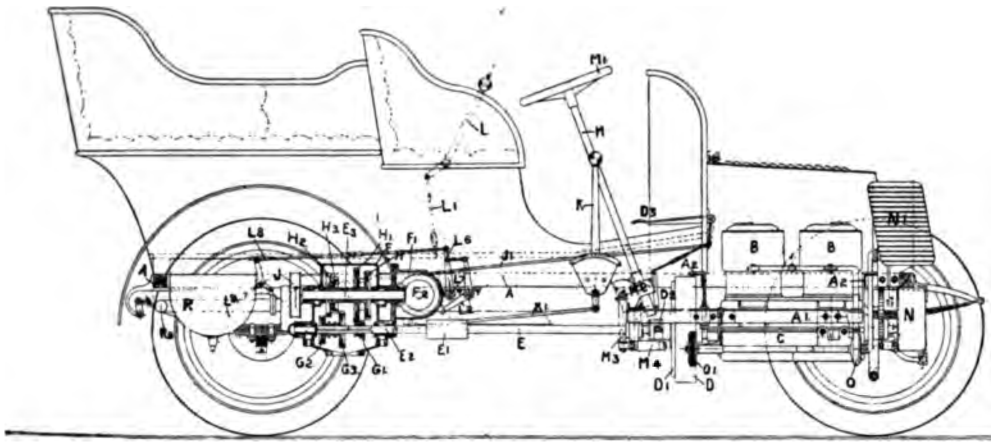


FIG. 32 A.—SIDE ELEVATION OF 12-H.P. DAIMLER CAR

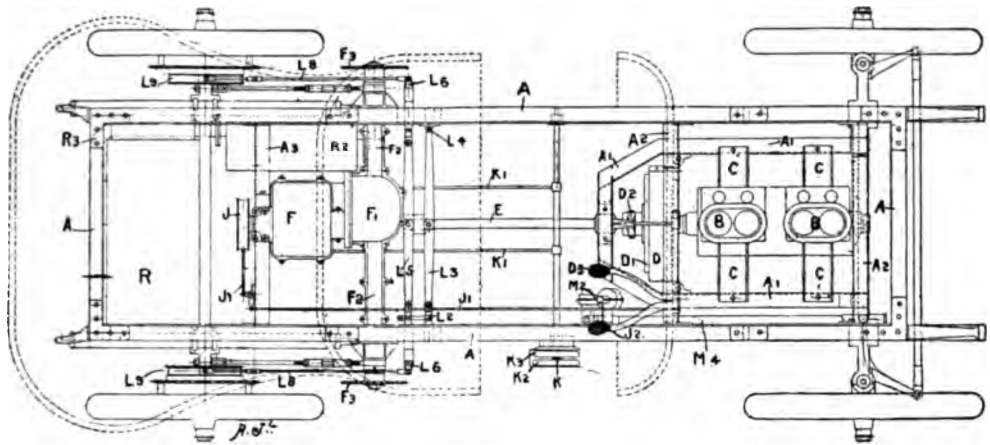


FIG. 32 B.—PLAN OF 12-H.P. DAIMLER CHASSIS

gear shaft are fixed four pinions, H 1, H 2, H 3, and H 4. In the diagram it will be noticed that none of the lower pinions are in mesh with the upper, consequently even although the clutch may be in action, the power will not be transmitted to the road wheels. When, however, the gear lever is operated so that pinion G 1 meshes with H 1 the low gear is brought into action, and the upper shaft E 3 is revolved. Similarly, G 2 is brought into action with H 2, G 3 with H 3, and G 4 with H 4 to attain the other speeds.

For the reverse, an idle pinion (not shown in the engraving) is made to mesh with G 1 and H 1 and so makes shaft E 3 revolve in the opposite direction.

This describes in detail the whole system of gearing and transmission which is in most general use. In many of the lighter cars, however, though the gearing may be much the same, the counter-shaft, sprocket wheels and chains are dispensed with. The power is taken direct from the secondary gear shaft through a shaft which is run longitudinally down the centre of the car, and which is connected to the secondary gear shaft by means of a universal joint, and communicates the power through the medium of a bevel wheel to a large bevel wheel on the rear wheel axle.

Figs. 33 and 34 give a good idea of the system of construction followed in single cylinder vor-turettes and light cars. It will be noticed that

chains have been dispensed with, the transmission being carried out by means of the Cardan shaft Q.

By consulting the following lettering in connection with figs. 32, 32 A and 32 B, the various other portions of the Daimler car may be followed:—

A, rectangular main frame, of wood strengthened with fish plates. A 1, under frame, suspended from A 2 and carrying motor. A 2, cross angle pieces, to which the under frame is secured. B B cylinders. C, crank chambers. D, flywheel with shaft forming female portion of a clutch. D 1, male portion of clutch. D 2, fork which operates sliding shaft E. D 3, pedal by means of which pressure is brought to bear on fork D 2. E, clutch shaft. E 1, sleeve connecting clutch shaft E with primary gear shaft E 2. E 2, primary gear shaft. E 3, secondary gear shaft. F, gear case. F 1, transverse casing containing the differential gear. F 2, the countershaft. F 3, the sprocket wheels. G 1, G 2, G 3, G 4, sliding gear wheels, on primary shaft. H 1, H 2, H 3, H 4, fixed gear wheels on secondary shaft. J, band brake on secondary shaft. F 1, rods actuating band brake. J 2, foot pedal actuating band brake. K, change speed lever. K 1, rods connected to a rocking shaft and concentric sleeve, and through which the sliding rods operating the two trains of wheels are brought into play. L, hand lever operating double-acting brakes. L 2, on rear wheels. L 1, adjustable rod through which the lever acts. L 2, bell crank to

DAIMLER TUNNEAU, 1902

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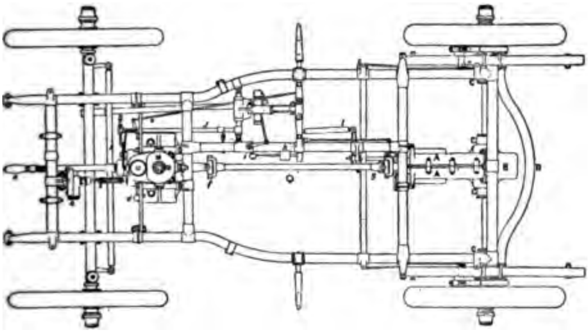

FIG. 33.—PLAN OF 6-H.P. DE DION CAR

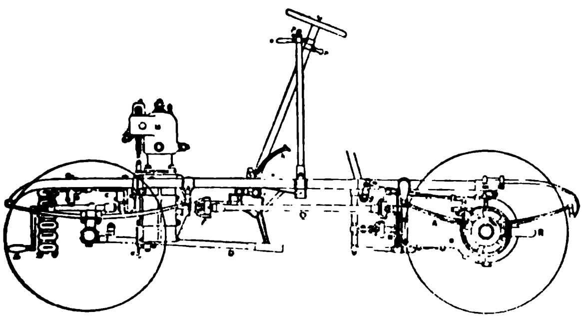

FIG. 34.—SIDE ELEVATION OF 6-H.P. DE DION CAR

a, Starting handle : *b*, pump ; *c*, spring driving pump ; *d*, rod to open waste oil tap of motor ; *e*, rod for advancing ignition ; *f*, *g*, joints of shaft connecting engine with gear ; *h*, pedal actuating exhaust valve regulator and brake on counter shaft ; *i*, *j*, *k*, mechanism of movement connecting pedal with valve regulator ; *l*, mechanism of movement connecting change speed handle and gear ; *m*, *m*, rods of back wheel brakes ; *n*, spring compensating movement of ditto ; *o*, change speed handle : *p*, ignition handle ; *q*, carburettor handle ; *r*, handle actuating exhaust valve regulator : *A*, *A*, *B*, aluminium case enclosing change speed and differential gears ; *C*, *C*, *C*, *C*, cardan axle joints ; *D*, steering rod ; *M*, motor ; *N*, rack with ball bearing actuating expanding clutches of gear ; *Q*, shaft connecting motor and gear ; *R*, fixed axle connecting the hollow wheel journals.

[redacted]

DE DION-BOUTON 8-H.P. CAR

[redacted]

which the rod is attached. L 3, lever operated by the bell crank. L 4, pivot on which L 3 works. L 5, a swinging coupling connected with L 3. L 6, levers connected with L 5. L 7, pivots on which L 6 act. L 8, operating rods. L 9, double-acting band brakes. M, steering pillar. M 1, steering wheel. M 2, worm gear case. M 4, rod through which the steering is operated, and which is connected to an arm projecting from M 2. N, water tank. N 1, radiators. O, chain-driven centrifugal pump. O 1, sprocker for chain driven from crank shaft of motor. P, end of crank shaft. P 1, starting handle, passing through tube in water tank, and fixed on to P. R, petrol tank. R 1, aperture for filling petrol tank. R 2, silencer. R 3, exhaust pipe.

How to Drive

BEFORE attempting to drive, the beginner should make himself thoroughly acquainted with the functions of the various levers, and should find out from his instructor the position of governor lever, ignition and throttle which are most advantageous under different circumstances. Before making an actual start, there is a certain routine which he should invariably go through.

1. He should inspect the oil, petrol and water tanks, and make quite sure that they are full. He should make sure that the crank chamber has received the proper measure of oil, and take a note of the quantity, for if he puts in too little, the engine may seize for want of lubrication, and if he puts in too much, the oil will get past the piston, and get burnt up, fouling the plugs and causing an objectionable odour. Before actually starting he should turn on his cylinder lubricators (if such are fitted) and make sure that the various other lubricators are working properly, and oil the bearings throughout the car.

If there is a removable plug for breaking contact, he should next insert it in position. He should then turn on his petrol tap, and, if a spray carburetter is fitted, should lift the float spindle so as

DE DION-BOUTON NEW MODEL 6-H.P. CAR, FITTED WITH FRENCH-BUILT ROLANDE CARRIAGE BODY

to allow it to flood, and so give a rich enough mixture for starting. If it will not flood, he may take it for granted that there is something wrong with the petrol supply.

The next step is to regulate the carburation lever, if such is fitted, bearing in mind that a rich mixture will be required when starting, because the pace of the piston is so slow that the suction is not great enough to draw in a large amount of petrol. He should next shift the switch button to M or "on" throw the motor out of gear, lower the sparking lever as much as possible, and put the governor lever (if such is fitted) in a position which experience tells him is the easiest one for starting purposes.

The engine is now ready for starting, and only needs an impulse to give it motion. The operator should place the starting handle pointing towards the ground, and standing so that he may be quite clear in case of a back-fire, should grip the end of the handle with one hand, and give a sharp, quick pull, holding the handle loosely. If the engine will not start after two or three efforts, alter the position of the carburation lever, if such is fitted, and if not, temporarily regulate the air inlet, so as to vary the quantity of air.

Having taken your seat in the car, accelerate the speed of the engine to something approaching the normal, and holding the clutch out by means of the foot pedal, very carefully put the low gear

into operation, and let the clutch home slowly and gradually so that its first contact will be of a slipping nature, and the car will take up its speed gradually. If the clutch is put in quickly, the strain to the entire mechanism of the car is excessive, and will sometimes even stop the engine. The motorist should make it a rule always to start on the lowest speed, for starting on a high speed will inevitably cause an increased strain, unless the car is on a decided fall of ground.

HOW TO CHANGE GEARS

It is impossible to give instructions of a general nature as to changing gears, because types vary so much. The Daimler, however, may be regarded almost as a standard. In this, when changing from low to high, the clutch pedal should be depressed with a sudden and firm movement, and the gear lever operated at the same moment. The latter should also be a decided movement, but at the same time so regulated that if the gear does not change satisfactorily, and the teeth grind, the operator can stop at once and try again. When a change of gear is however missed, it is very often exceedingly hard to get the teeth into mesh without grinding, and the careful driver who does not wish to damage the teeth will find it more advisable to stop altogether, and if necessary go back to the low gear again, and make a fresh start. With some practice, the sudden and decided move-

ment both of clutch pedal and change speed lever necessary for a successful change, will come quite naturally.

When changing from the high to the low, many experts hold that it is necessary to operate the clutch pedal. We have not found that so, in moderately powered cars at all events. As a rule if the gear lever is moved steadily into the notch, the teeth will mesh without a sound. The movement is different from the other. It should not be so rapid and decided. If by any chance the operator finds a difficulty in changing, or delays changing until the engine begins to labour, and the strain on the teeth is excessive, it may then be necessary to fall back on the clutch pedal. It should be operated, however, with a sudden, smart tap of the foot, and not the sharp push home found necessary in changing from the low to the high.

In changing the gear, whether from low to high, or high to low, it is advisable that no attempt should be made until the pace of the car has approximated to that of the gear to which the driver wishes to change. Many drivers fall into the great mistake when ascending a hill of endeavouring to get on to a higher gear before the car will really take it. Although it may be possible to stagger upwards on this gear, the pace will be really slower than if a lower gear had been used, while the strain on the engine and transmission is vastly greater.

In the De Dion an expanding clutch is used worked by a hand lever on the steering pillar. The pinions on the gear are always in mesh, and the change of gear is effected very easily. The whole system is fully described in "The De Dion Voiturette: Its Mechanism and How to Drive It," by R. J. Mecredy.

THE SPARKING ADVANCE

It should always be borne in mind that the spark should be timed to suit the pace of the engine. In other words, that the motorist should endeavour to fire the charge at the moment that the piston has reached the highest point of its stroke. This secures the maximum of efficiency. If, however, he fires it too soon, there will be back pressure on the top of the piston, counter-acting to some extent the force of the explosion, and causing a hammering on the bearings, which is most destructive. This state of affairs is usually betokened by a curious noise, commonly referred to as a "knock," and which once heard is unmistakable.

In the case of single cylinder ungoverned engines, such as are fitted to cycles and some cars, the speed of the engine is largely regulated by the sparking advance lever, and in this connection the novice often labours under the mistake that if he wants to increase his speed he need only advance the sparking lever to do so. This is no doubt true where the work is light, as on the level, but when

THORNEYCROFT $3\frac{1}{2}$ TON COVERED VAN FOR GENERAL GOODS-CARRYING SERVICE

the work becomes heavy, and the engine slows somewhat, if the sparking is advanced to the fullest extent, it will result in the explosion occurring before the piston has quite reached the highest point, and consequently power will be lost, and a back-pressure will be caused on the piston; this, as already pointed out, will produce what is commonly known as a "knock." The driver, therefore, must remember to operate his sparking lever according to circumstances. If he wishes to travel at a moderate pace along a level road he should operate the throttle lever and retard his sparking lever to suit the lower speed of the engine. If he wishes to increase his pace on a level road he should advance his sparking accordingly, and open the throttle. If he is driving at top speed along a level road, with the sparking well advanced, and he commences to ascend a hill which slows down both engine and car, he must retard the sparking so that the explosion will occur when the piston is in the best possible position to receive it. If the hill is so steep that the engine begins to labour, and he has to change on to his low speed, he should not advance the sparking to such an extent as to cause the engine to race, while, on the other hand, he should not retard it to such an extent as to weaken the force of the explosion too much by making it occur after the piston has descended considerably. All this is a matter of experience, but the driver should

realise that he has a good deal to learn in this direction, and that he will get the best results as regards speed and hill-climbing, and the durability of his car by a careful study of the relative positions of his sparking advance lever, his carburation lever, and the throttle lever.

THE CARBURATION

The latest carburetters fitted to cars like the Mercedes and Panhard are regulated so as to give a perfect mixture, no matter what the speed of the engine may be. In many cases, however, the carburetter is regulated to give a perfect mixture at a normal speed, and as the speed falls below this, the suction on the spraying jet becomes so much reduced that but a small quantity of petrol is drawn through. Meanwhile the full complement of air is finding its way into the mixing chamber, with the result that the mixture becomes so attenuated that when the engine drops to a certain speed, it becomes non-explosive, and the engine will stop, unless accelerated. This causes many cars to be noisy when standing idle. Some of these carburetters are fitted with air valves, governing the secondary air inlet at the upper portion of the carburetter. When the speed of the engine drops, it is advisable to work the air lever so as to reduce the quantity of air entering through this secondary air inlet. By this means the mixture is kept correct, and the engine can be

THORNICROFT LIGHT OMNIBUS FOR FOURTEEN PEOPLE—LUGGAGE ON ROOF

made to run at a slow speed when the car is standing stationary.

To put it in general terms, the motorist should endeavour to get the best mixture possible, and to explode it at the right time.

HOW TO LEARN

When learning to drive, the beginner cannot be too cautious. He should travel at a very slow speed, and should practice starting, stopping, sharp turns, changing speeds, and also driving backwards. The latter is a most useful accomplishment, and the sooner it is acquired the better. It is a foolish policy for the motorist to wait for the necessity to arrive for manœuvring in tight places to learn how to drive backwards.

On grease he should be particularly careful. Side-slip is the greatest danger that the motorist has to encounter, and nothing but experience will enable him to counteract the tendency. If it is required to check the speed of the car, it should be done by means of the accellerator, the ignition lever being moved in conjunction. When the pace drops to that of the next speed, it would be well to change at once, for unless on a down-grade it will be hard to pick up on a higher speed when the driver wishes to go ahead again.

It is a very foolish practice to jam on the brakes when one wants to pull up. The stopping should be done as already described, or otherwise most

injurious strains will be thrown on the engine and transmission gear, and the tyres will wear very rapidly. Many drivers are very fond of showing off in this direction, but they pay heavily. A really good driver will very seldom use his brakes. If it becomes necessary to do so, it should be remembered that the hand-applied brakes acting on the rear wheels, cause less strain than the countershaft brake.

Steep hills should never be descended quickly. If the car once gets out of control the momentum acquired becomes so tremendous that it is nearly impossible to pull it up. The brakes, too, may go on fire, or suddenly become inoperative. It is good practice when descending such hills to use the foot and hand brakes alternately, thus giving one a chance of cooling while the other is in action. If it becomes necessary to use both, the car should be pulled up to a very slow pace. In most modern cars, means are provided for cooling the countershaft brake by letting water into the drum—this should not be overlooked. On a long, steep hill, it is good practice to run the car against compression occasionally, and thus ease the brakes. This is done by switching the current off, stopping the engine, and then letting the clutch in gradually. The impetus of the car will then be wasted in driving the engine. Needless to say, the current must be switched on before the bottom of the hill is reached and the car has lost its momentum, or

the engine will have to be restarted with the starting handle.

Corners constitute a very serious danger, especially to the beginner. Only judgment and experience can enable one to calculate speed to a nicety, and know if a corner can be taken at a certain pace. It is always better to err on the slow side. In taking a corner, too, it is advisable to take the clutch out of operation on the bend of the corner, and let it in again as the car straightens itself. This is especially so if the corner is greasy. In cars with single-cylinder engines, and in motor bicycles, the speed is very greatly regulated by the sparking lever, and much depends on its manipulation, if the best results are to be got out of the engine. In this connection, the novice often makes a mistake.

SIDE SLIP

Side slip, as already mentioned, is absolutely the most serious danger that the beginner has to face. The class of mud on which a motor car slips is exactly the same as in the case of a bicycle, and consequently the man who is a cyclist will be in a better position to judge than anyone else. Briefly, if the mud is thick and half dried, or if there is a thin film of grease over setts or wood paving, or if the road surface is of a slimy description of limestone or oolite, the driver must exercise great

caution. Frozen roads are, as a rule, safe. A sheet of ice, however, must be negotiated cautiously, and if the surface of it is sufficiently thawed to become wet, it is even more treacherous than the worst class of mud.

The only safeguard against side-slipping is to travel slowly, at a steady, uniform pace. A sudden, violent application of the brake or a very strong impulse from the engine may set up slipping. The driver should, therefore, try to run his engine at an absolutely uniform speed, and should avoid travelling at a pace which would necessitate a strong application of the brake, should an obstruction suddenly block the highway. The action of a car in grease is often deceptive. The driver finds that he can maintain a fast pace without any sign of side-slip, but he is almost helpless should the need arise for a sudden stop. If he puts the brake on suddenly, the car will swing right round. A curve also will have the same effect, or an attempt to take a corner quickly.

When a side-slip does occur, the driver should disconnect his engine on the moment. If he has applied his brakes, he should let them off again, and in order to right the car he should swing the steering wheel very rapidly but almost imperceptibly to the side to which the car has slipped, and instantly swing it round again in the direction in which he wishes to go. The object of this is to enable the front wheels to get sufficient bite

THORNEYCROFT MUNICIPAL WATERING-VAN, 800 GALLONS

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on the road to make steering possible. If the wheel is violently turned in the opposite direction to the slip, the car is nearly certain to continue slipping, and perhaps to turn with the back to the front. Should the latter happen, the driver should let his clutch in again as the car straightens, when the front wheels will probably grip, the car being, of course, turned in the opposite direction to that in which it was before.

From these directions, it may seem that driving in grease is exceedingly dangerous. To the experienced driver, this is not so. He quickly learns the speed at which he can travel with safety, and the amount to which the brakes can be applied without causing side-slip. He also learns to counteract the tendency to side-slip by adopting a slight sawing movement of the wheel when the car shows suspicious symptoms, and when the side-slip actually occurs he can, as a rule, correct it in the manner we have already described. Even should all these expedients fail, and the car swing right round, it will not turn over, or sustain any damage, unless it strikes the curb or another vehicle, or the road is so narrow that he goes into the ditch.

The Care of the Car

THE successful running of a motor car is mainly a matter of common sense. If a man possesses thoroughbred horses, he knows it is essential that they should be properly fed, and at regular intervals. If they are overheated from hard driving, they must be cooled down before being put into the stable, and there are other precautions which if neglected would probably lead to the illness or death of the animals. On the other hand, most beginners in motoring seem to labour under the delusion that a car is practically an automatic machine, which needs little or no care or attention until it actually goes wrong, when they are inclined to blame it. As a matter of fact, the attention it requires must be almost as consistent as in the case of horses, although as much time need not be consumed in keeping it in proper running order. As the horse must be fed with provender, so the motor car requires a plentiful supply of good lubricating oil, petrol for propulsive purposes, and water for cooling the engine. It is not always safe to wait until the engine makes its wants known. These wants should be anticipated, and if this is done in a common-sense manner, there need be very little tinkering with the mechanism of the car, and it will prove on the whole as

reliable as a horse while needless to say, capable of doing a vast deal more work.

It is good practice after each run, to have the car hosed down at once, just as horses are attended to before they are put into the stable. The carriage work should be treated in the same way as an ordinary carriage. The engine should be cleaned, especially if it is muddy, or covered with grease. Waste petrol will be found very useful for the purpose. About a tablespoonful of paraffin should be run into each cylinder, and the starting handle operated for a few seconds. This has the effect of cleaning out thick gummy oil which would otherwise clog round the piston rings and valves, and render starting on the following morning a difficult operation. The petrol tank should be carefully filled, and for this purpose a clean tundish, with gauze strainer should be used. The careful man will also place a piece of linen in the strainer, which will not only intercept impurities, but will also prevent the water which is nearly always to be found in petrol from reaching the tank. It is also a wise precaution to open the cleansing tap at the bottom of the carburetter, so as to allow of any water or impurities which may have lodged there, escaping. If this is not done, the jet may get choked, or the water may prevent the engine from running. Sometimes a special chamber for intercepting these impurities is fitted, and this should be cleaned periodically. If there

are grease pots, these should be examined, and re-filled if necessary. The reservoir for lubricating oil should also be seen to. If the liquid at the bottom is of a milky appearance, it is an indication that water has collected, and the cylinder should at once be cleaned out. If it is in the winter season, and there is any indication of frost, all the water should be let run out of the tank and circulating system, for should it freeze in the night the probabilities are that the water-jacket will be burst, an accident which would entail much expense. If the coach-house in which the car is stored, is artificially heated, this is not necessary. If it is in the summer season, however, the tank should be refilled with clean water, poured through a tundish with gauze strainer. Impurities getting in with the water are likely to find their way into the pipes, and may cause an obstruction therein, or in the pump itself. I have known of much trouble being caused through an ordinary leaf getting into the tank, and partially stopping up the exit pipe.

Tyres, bearings, nuts, bolts, and such like, should receive a cursory examination, and the car should be left in thorough running order, so that it could be taken out at a moment's notice. If this is done, the owner will be saved much inconvenience and disappointment. It very often happens that there are trifling adjustments necessary. An examination of this kind locates them; otherwise

THE KING'S NEW LOADERS' DAIMLER CAR

Personally I have found the varieties supplied by the United Motor Industries, Ltd., 49 Gt. Castle Street, London, and by Messrs Price's Patent Candle Co., of Battersea, exceedingly suitable. These are made to suit different purposes, and consequently if the purchaser does not know the exact kind that he requires, he should give full particulars of the engine when ordering, and can rely upon the firm to supply the proper article.

The small air-cooled engines depend altogether for their lubrication upon the splash from the crank chamber, and the water-cooled engines depend partially on this source. It is therefore essential that the supply in the crank chamber should be maintained. The quantity differs with different engines. For example, in the small engines, about two ounces of oil is generally sufficient, while in the larger engines, half a pint is the most usual quantity. If the proper amount is exceeded, the oil will find its way past the piston into the combustion chamber, where it will be burnt, and cause a sooty deposit on the sparking plugs, and a most disagreeable odour. If the supply is insufficient, the lubrication of the piston and cylinder sides will not be adequate for their easy working. Consequently, there will be friction, heat will be generated and the engine will lose its power. As the heat increases, the oil will get burnt up more rapidly, and matters will quickly become worse until in extreme cases the piston will stick, in the

cylinder, or in technical terms "Seize." This is very often a serious matter. The sides of the cylinder may be scored. Sometimes the piston can be freed by a plentiful application of paraffin followed by lubricating oil, and then a vigorous operation of the starting handle. In other cases, it becomes practically immovable and the engine has to be taken down to free it. It may even break the connecting rod.

In the air-cooled engines, this oil generally requires to be renewed after running a distance of from twenty to thirty miles. If there are any indications of heating or sluggish running, it is well to open the waste tap, and to let the remains of the old charge run out. If only a few drops trickle out, it will be quite evident that oil was needed, whereas if it flows in a steady stream, the driver may conclude that he was mistaken. In any case, however, a fresh charge will not be amiss, and before letting in a fresh charge, it is always advisable that the remains of the old charge should be run out, especially with the smaller engines.

After a little experience one will quickly get to know if more oil is needed or not. It is always better to err on the safe side. In these small, high-speed engines, the variation in the distance which can be run on a single charge is very great. If there is continuous hill-climbing, if the engine has run at its utmost for a lengthened period, or

if one is travelling before a strong wind, the heat generated will be above the normal, and consequently the oil will get burnt up quicker than usual. Also, when the engine is new, there is greater friction, and the oil is used up more quickly. Under such circumstances, it would be wise to renew the charge about every fifteen miles. It is false economy to try to save in lubricating oil, especially in the case of air-cooled engines.

Want of oil, over-heating, and friction generally go together and are often accompanied by a curious hammering noise, technically known as a "knock" similar to the noise caused by advancing the sparking too much, and thus making the explosion occur before the piston has reached the highest point. The sooner one gets to recognise this noise, the better, and consequently it would do no harm to very cautiously advance the sparking until this noise becomes apparent, when the driver will always be able to recognise it again. He should not, however, keep the ignition so advanced for more than a moment, as the strain on the connecting rod and bearings of the engine is considerable. These remarks as to "knock" apply to all types of engines.

In the larger engines the splash from the crank chamber cannot wholly be relied upon for the proper lubrication of the cylinders, and consequently a pipe is run from a sight feed

LORD HILLINGDON'S P.T.L. SERPOLLET DOUBLE PHAETON

lubricator on the dash board to each cylinder, and can be regulated to let a certain number of drops fall per minute. The owner of the car should find out from the makers the proper quantity and should be very careful to keep his lubricators adjusted to this. These lubricators can, as a rule, be lifted to allow of a rush of oil, and it is good practice to raise them slightly at the commencement of a day's journey, because if the engine has been lying for the night, the cylinder sides and piston will be necessarily dry, and will require more copious lubrication than the usual drop feed will permit of. In fact, in many cars it is advisable to lift these lubricators for a moment every fifteen or twenty miles. It is good for the cylinders, and it replaces the waste in the crank chamber. When a car is new, too, the friction is considerable, and consequently the oil is used up more quickly than otherwise. Under such circumstances a rush of oil might be let into the cylinders about every ten miles.

And now as regards the crank chamber. As before mentioned, about half a pint is the usual quantity required here, but there is no hard and fast rule, because in some crank chambers there is very little clearance between the bottom of the crank chamber and the fly wheel, and consequently a comparatively small depth of oil will suffice for the splash. The drop feed lubricators, and the occasional flushing of the cylinders will

is liable to collect both in the gear case and in the crank chamber of the engine. It is therefore advisable to wash both out completely with paraffin at intervals say of a thousand miles. In the case of the crank chamber, the lubricating oil should be allowed to run out. The waste tap should then be closed, and a plentiful supply of paraffin injected into the cylinders. The starting handle should next be turned vigorously, but the engine should not be started, or the piston may seize. The paraffin should then be allowed to run off, and if there are still signs of much dirt, the operation should be repeated. A fresh charge of lubricating oil should then be injected.

As regards the gear case, the oil should be run off, and about half a gallon of petrol run into the case. The engine should then be started and the car run for not more than half a minute. This will effect a thorough cleaning. The paraffin should then be run off, and oil substituted.

As regards the car proper, every moving part must be kept lubricated, just as in the case of a bicycle, and to this end, the owner should personally locate every part where there is friction, and if necessary make a note of it. In many cars the greater part of the lubrication is automatic, but a careful watch must be kept on the pipes to see that they do not choke, or on the grease pots to make sure that they are full, and that the inlet to the bearing is not choked. There are parts,

however, which need special treatment, such, for example, as the bearings of the wheels, the steering connections, the lever bearings, and such like. These should receive careful attention. When a car is new, more lubrication is necessary than afterwards, and for the first few days it is good practice to fill the various bearings about every twenty miles or so. If there is friction, they will heat, and if the temperature is so great that they are really hot to the touch there is danger of seizing, and the car ought to be stopped at once. The bearings should be carefully examined, and if practicable, eased, but if there is any difficulty in this connection, it would be better to bring the car back to the agents, stopping at intervals, to let the bearing cool, and keeping it plentifully supplied with lubricant.

Finally, if one should run short of oil when on tour, it will generally be found that really good gas engine oil will do in an emergency.

WATER CIRCULATION

Next in importance to lubrication comes the question of water circulation. Any failure here will cause overheating, with the result that the oil will get burnt up, the car will run sluggishly, and in extreme cases if the trouble is not remedied the friction will become so excessive that the piston will seize. As a rule a water gauge is fitted, and this should be carefully watched when the car is

IVEL MOTOR WORKING A REAPER AND BINDER ROUND CORNER

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running, though it is not an infallible index, for though it will at once show any complete stoppage, it will not, as a rule, indicate weak circulation. If no water gauge is fitted, or if there is reason to think that the circulation is weak, the best index will be found in the engine itself, which will at once become hotter than normal. After a little experience, one can locate the trouble by feeling the engine or pipes with the hand. If the car begins to run sluggishly, this method should be immediately adopted. Sometimes a test tap is fitted, and if this is opened, the force with which the water is ejected will tell if the circulation is powerful enough. To enable one to diagnose this trouble, the engine should be felt, and this test tap opened when the circulation is all right, so that one can be able to form a proper idea of the normal condition of affairs, and so be able to judge if there is anything wrong.

The pump is the point which needs most attention. If it is driven off the fly wheel by means of a friction wheel, it is necessary to make sure that the latter is not slipping. A spring is fitted which should be kept adjusted, so as to make the contact just sufficient to overcome the vibration of the road. If the wheel slips the pump will not work strongly, and if it stops driving the circulation will cease altogether, and the engine will overheat almost immediately. On the other hand, over-tightening brings a severe strain on the bear-

ings. The leather on the friction wheel should be carefully cleaned with petrol, and then dressed with slaked lime, and the portion of the flywheel on which it bears similarly treated. The lubrication of the pump spindle should also be carefully attended to, for otherwise it is liable to lock, and the pump to cease acting. Sometimes the pump is chain-driven, and here the only trouble that is likely to happen is the breakage of the chain—a most uncommon occurrence, and one which can be easily repaired by fitting a new link. In other cases the pump is gear-driven. Here, too, there is little danger of trouble, but if it does occur, it may necessitate a new gear wheel.

There are two types of pumps in general use, the centrifugal, and the semi-rotary. The former is a fan revolving in an enclosed chamber, at a speed of about 2000 revolutions per minute. In itself it is unlikely to get out of order, but the high speed is hard on the bearings, and consequently they require frequent attention. If there are any signs of heat being generated, they should be at once taken asunder, and carefully inspected.

In the semi-rotary pump there are four valves which are likely to give trouble. Dirt or grit will prevent them from closing properly. They should be washed out at intervals, and occasionally it may be necessary to remove the fans of the pump, and clean the inside thoroughly. If they are worn, they must be reseated, or have new washers fitted.

CAR OF THE ROAD CARRYING COMPANY, LOADED WITH $2\frac{1}{2}$ TONS OF COAL

The grease cup should be kept filled, and screwed home at intervals, or the pump may leak. The packing nut gland also should be carefully adjusted, and if the packing wears, it must be replaced. Tow mixed with tallow will be found satisfactory.

Pipes and connections sometimes give trouble. If a fracture occurs, a repair can be effected by connecting the defective parts with a piece of rubber tubing, wired into position, and for this purpose, tubing should always be carried. In filling the tank, the air tap and radiators should invariably be opened to prevent an air lock. If the latter is suspected, it is a wise precaution to stop up the overflow pipe with a cork, or by getting someone to hold a hand over it, and flood the tank until the water comes out at the inlet. Occasionally the radiators require cleaning—grease may get into them from the pump, and condense along the inside. The best remedy is to connect them up with a steam pipe from an engine boiler for about two hours. Sometimes they get choked up with mud, which must be carefully removed, or the water will not be able to flow. The water in the tank should never be allowed to get low, but should be replenished when occasion offers, as for example, during the mid-day halt for lunch.

IGNITION

As I shall deal with this subject in another chapter, I shall only call attention in this chapter

to various points which should be seen to when the day's journey is concluded. The battery first merits attention. If it has been in use any time, and the motorist has reason to think that it is nearing the limit of efficiency, it should be tested the moment the engine is stopped after the day's run. There is a reason for not allowing an interval to occur, because a battery which has run down recovers its voltage temporarily after a short rest, and will even run the car satisfactorily for half a mile or so.

There are two types of battery in general use—the accumulator or secondary battery is charged through an electric installation or dynamo, and as a rule consists of two cells. Each cell when freshly charged should read 2·2 on the voltmetre, though immediately it is put into use it drops somewhat. If it drops below 2, the battery should be re-charged. If an accumulator is left in an exhausted condition for any length of time, the plates sulphate, and permanent injury is caused. Even when not in use, an accumulator should be charged periodically, as there is always a certain amount of leakage. Charging should be done slowly, and uniformly, for fast charging loosens the paste on the plates, but slow charging improves the battery. The electrolite should always cover the plates.

The primary, or dry cell battery, generates its own electricity. It usually consists of four cells, and each should read 1·5 when new, or a total of

6. When each cell has dropped to 1·1 the battery should be replaced by a new one. The primary battery since it generates its own electricity by chemical action, gives out more gradually than the accumulator.

Now, a battery, whether primary or secondary, requires volume, commonly referred to as "amperage," as well as pressure, commonly referred to as "voltage" to enable it to give a fat, hot spark. The voltage is measured by means of an instrument called the voltmetre, and the amperage, by means of an amperemetre. The amperemetre is not suitable for testing a secondary battery, because it is likely to damage the cells. On the other hand, a voltmetre, although it may show the pressure, gives no idea of the volume left in the accumulator, and consequently the motorist may find that his battery has run down immediately after a voltmetre has registered 4. To get over this difficulty, we should recommend the use of a tiny four-volt lamp, which may be purchased from any accessory maker, for a few shillings. This if connected up with the positive and negative poles of the battery, will give an index both of the voltage and amperage, for if both are not sufficient, the light will fail, and even in extreme cases the wires will only glow. This lamp should be used in conjunction with the voltmetre, and in comparative darkness, so that the light can be plainly seen.

The use of the voltmetre is very simple. Each

cell should be tested separately by placing one of the wires in contact with the positive pole (the positive pole has a + on it, or is coloured red) and the other in contact with the negative pole, marked —. This completes the circuit through the voltmetre, which thereupon registers on the dial the voltage of the cell. One or other of the two wires, however, should only be kept in contact for sufficient time to enable the indicator to be read, as lengthy contact may injure both the voltmetre and the cells. The four-volt lamp is used in the same way, that is a wire is placed in contact with each of the poles. In this case, however, lengthy contact will not cause any injury.

The amperemetre is generally used with the primary battery. It tells the volume or quantity which has passed through the cells at the time of testing. As to the amount that remains, it gives no direct index. Indirectly, however, it gives some idea, because it shows a variation, according to the amount used. It consumes a large amount of current, however, and unless used very carefully, may injure the battery.

Not unfrequently there are short circuits in the battery, particularly in the terminals, which may be eaten away by the corrosive substances of which the batteries are formed, leaving a deposit which causes a short circuit. Every terminal should therefore be periodically examined and thoroughly cleaned before being tightened up

PHOTOGRAPH OF DIFFERENT PARTS OF CARRIAGE BODIES OF 10-H.P. STANDARD DECAUVILLE CAR, SHOWING HOW THE ORDINARY PLATFORM PATTERN MAY BE TRANSFORMED INTO EITHER TONNEAU, OMNIBUS OR PHAETON

again. If vaseline is applied it will tend to prevent this corrosion. Sometimes, too, the bridge connection between the terminals and the accumulator may get broken; this can be repaired temporarily by substituting a length of wire.

If the paste with which the interstices of the plates falls down between them, a short circuit will occur, which cannot well be set right, except by an expert.

The wires should next be carefully examined. They very often break, or come loose at the connections, or even inside the rubber insulation. A loose wire is easily remedied. A breakage at the terminals which is apparent can be put right by peeling back the insulation, making a small loop on the wire which is made bare, placing it round the terminal, and screwing home the nut on top of it. To make a really satisfactory job, this loop should be slightly flattened with a hammer, the overlapping piece bound with fine wire, and then soldered up. If the breakage is inside the wire itself, it can often be detected by bending it piece by piece. Failing that, test for a short circuit by means of the voltmetre in the following manner. Attach one terminal of the voltmetre to the end of the wire to be tested, which should, of course, be in contact with one of the terminals of the battery. Then make momentary contact between the other wire of the voltmetre and the opposite pole of battery, as already described. If the wire

is broken no current will pass. If, however, there is a short circuit the indicator will show a lower voltage than it will show when its wires are attached to the terminals of the battery.

THE CARBURETTER

There are two types of carburetter in general use, the surface and the spray. The former is hardly ever fitted except to motor cycles, and even for these the spray is superseding it. It is exceedingly simple, and gives very little trouble, except when starting in cold weather. Sometimes this carburetter floods; this is generally due to the valve which admits the petrol from the tank to the carburetter becoming worn. The remedy is to regrind it.

The spray type of carburetter is more certain in action, but requires much more attention. The principal trouble arises from dirt or water getting into the petrol. The former chokes the jet, thus stopping the supply, and the latter, though it does not choke the jet, causes the same result. To prevent this occurring the petrol should be carefully strained, and the waste tap in the carburetter opened occasionally to allow of the removal of the impurities. If this is not sufficient, the jet will have to be taken out, and a very fine wire run through it, and the carburetter thoroughly cleaned, especially the gauze, which often stops the flow of petrol through getting choked up with dirt.

The best means of making sure that the supply of petrol is correct is to flood the carburetter by lifting the float spindle. If the petrol runs out at the overflow pipe, it may be taken that all is right as regards supply. If, however, it will not flood, and it is found that the carburetter and jet are clean, the trouble may be located in the inlet pipe. The union between this pipe and the carburetter should be disconnected, and the petrol turned on. If it flows freely it may be taken that the pipe is clear. If it flows intermittently, or not all, the pipe is choked with foreign matter, and it will be necessary to remove it from the tank, and to blow down it with a tyre inflator, wired up to one end, or, failing that, to straighten out the pipe, and pass a piece of copper wire through it. Needless to say, this pipe should not be disconnected in the neighbourhood of a naked light. If the feed is by means of pressure, it is necessary to make sure that the pressure valve is acting properly. The gauge should read from 2 to 4 lbs, according to the particular type of engine. If the feed is by gravity, the flow may cease altogether if the air inlet in the tank is by any means stopped. We have known this occur where the tank formed the front seat, through the cushion coming down on the top of the air inlet.

The mechanism for regulating the supply of petrol to the float chamber is very delicate, and will sometimes need carefully regulating. If fig. 20 in Chapter I. is consulted it will be seen that this

Sometimes the float gets punctured, and filling up with petrol becomes so heavy that it will not close the inlet valve. It must be removed and the petrol drained out, and the hole soldered up. This should be carefully done, as if the weight is increased, it will of course affect the level of the petrol in the float chamber.

It has always been a most difficult problem to construct a carburetter in which the mixture will be correct at all engine speeds. Only quite recently has this difficulty been successfully tackled. Most of the carburetters at present on the market are adjusted for a normal engine speed. As this speed drops, the suction from the piston is of course reduced, and the rush of air from the bottom of the carburetter past the spraying jet is not so strong. Consequently the supply of petrol is very much reduced, and in proportion there is a greater rush of air from the upper air inlet of the carburetter. Thus the mixture becomes vitiated, and as the speed of the engine drops, the proportion of petrol to air becomes less and less, until at last the mixture becomes non-explosive, and the engine will stop, unless its speed is accellerated. It is from this cause that most engines have heretofore proved so noisy when the car is idle. Owing to the carburetter being defective it was impossible to get a perfect mixture at a slow speed, and consequently, the engine had to be run fast, causing much noise and vibration. Recently,

however, in the Mercedes, Panhard, and other cars, the governor has been made to regulate the supply of air from the extra inlet, so as to keep the mixture perfect at all speeds of the engine. This has the result of enabling the engine to be run at a very slow speed when idle, and consequently these cars are particularly silent.

In some of the old types of carburetters, a mixture lever is fitted, by means of which the quality of the mixture can be regulated. By operating this and reducing the air supply when the speed of the engine slows, almost the same results can be obtained.

THE VALVES

If the valves are neglected, they are bound to get sooty or gummy; the immediate result is to make the engine difficult to start because the inlet valve sticks to its seating, and the suction caused by operating the starting handle is not sufficient to open it, so that no charge is admitted. Even when a start has been effected the valve opens so sluggishly that the volume of gas admitted to the combustion chamber is reduced, and consequently the power of the engine is affected.

To keep the valves in good order, a teaspoonful of petrol should be injected into each cylinder after the day's run, and the starting handle should be operated vigorously. This cleans the valves,

the piston and the cylinder sides at the same time. Even however with the most careful attention, the valves are sure to get fouled in process of time, and in fact in the case of many air cooled engines it is of rather frequent occurrence. If left in this condition, not only will difficulty be experienced in starting, and power lost, but the valves will become pitted, thus reducing the compression, and further affecting the horse power.

It is therefore wise periodically to take the inlet valve out, and to thoroughly wash it in paraffin or petrol. Paraffin should also be poured on the top of the exhaust valve, and a screw-driver used to turn it from side to side, so as to clean the bearing surface against the seating. The opportunity should be taken of the removal of the inlet valve to inspect its face, to make sure that it is not pitted or worn. If it is affected in the slightest degree it might be advisable to remove the exhaust valve also and to grind both. In air-cooled engines grinding is frequently necessary, but in the large water-cooled engines it is very seldom required. The process is as follows:—Make a mixture of flour emery and oil—preferably olive—and smearing a small portion between the face of the valve and its seating, keep turning the valve round and round. Repeat the operation until both surfaces become bright and smooth, with a good face fit. Any dark spot indicates that more grinding is required. The valve should then be

carefully washed in petrol. If near a workshop, it will save a lot of trouble and ensure a better job to get the valve ground in a lathe by an expert mechanic.

To grind the exhaust valve, remove the cross key which passes through its stem, having first raised the hollow cap washer, which prevents the cross key from slipping, and then take off the spring and push the stem upwards till the head emerges through the inlet valve opening. Having removed the valve in this way, smear the seating —which, in the case of the exhaust valve is part of the engine itself—with some of the oil and emery mixture, and also smear the face of the valve. Then replace the valve on its seating. Having plugged up the opening to the combustion chamber with cotton wool or waste to prevent the emery getting in and scoring the cylinder, proceed to grind the valve on its seating. An ordinary screw-driver can be used for the purpose. The operation must be repeated until no dark spots are left which indicate that a true face fit is obtained. Then remove the valve and wash out all the emery paste from the entrance to the combustion chamber. Next remove the cotton wool and replace the valve, having first thoroughly cleaned the stem and washed it in black-lead mixed with petrol. If the stem is dirty, rough, or a very tight fit, polish it with fine emery cloth to prevent all danger of its sticking in the guides. See also that the guides

are clean and lubricated. New valves should also be ground on to their seatings.

If there is not any very great improvement in the compression just at first, the motorist must not be disappointed. It takes some little time before the newly-ground valves become perfectly gas tight.

After successive grindings, it is sometimes found that the exhaust valve sits down so far on its seating that the stem makes continuous firm contact with the plunger, which lifts it, and thus prevents the valve from wholly closing. To remedy this, sufficient should be filed off the end of the valve stem to admit of a visiting card passing between the stem and the plunger when the latter is at the lowest point. It should be borne in mind that, owing to the expansion caused by the heat, the valve stem may clear the plunger when cold, but touch it when the engine is working. It is to allow for that expansion that we recommend that the space should be as much as the thickness of a visiting card. Sometimes the stem is too short, and the exhaust valve does not open enough, thus causing back pressure. A new valve should be fitted.

Springs are a very frequent source of trouble. In the case of the inlet valve if the spring is too strong, it will not open until the piston has decended some distance on the suction stroke and consequently a full charge is not admitted to the

combustion chamber. On the other hand, if it is too weak, it will not close quickly enough at the conclusion of the suction stroke, and the ascending piston will force a portion of the charge back through the inlet valve. It is therefore impossible to satisfy both conditions, and consequently a compromise has to be arrived at. Any variation from this affects the power of the engine, and seeing that the heat of the engine may injure the temper of the spring, a considerable amount of expert attention is necessary to make sure that this tension is correct.

In multi-cylinder engines also, it is necessary that the tension of the spring of the inlet valve in each cylinder should be the same. To test this, a valve should be held in each hand, and the stems pressed together. The valves should open approximately at the same moment. The spring of the exhaust valve also may become affected by the heat, with the result that the exhaust valve will return to its seating sluggishly, and allow a certain quantity of burnt gas or air to be sucked back on the next suction stroke, thus affecting the power of the engine.

It is necessary, therefore, to keep a supply of new springs in case they are needed. The same applies to valves, for both exhaust and inlet valves occasionally break. This is indicated by a complete loss of compression in the cylinder affected. The exhaust valve guides also must be kept clean or

the valve spindle will stick up and compression be lost. In an extreme case it is sometimes necessary to ease the stem with fine emery paper. If the spindle is bent or broken, a new valve must be fitted.

So far, I have been dealing with the old type of inlet valves, which are opened by the suction of the engine. Mechanically operated inlet valves have recently come into vogue, however, as described in Chapter I., and get over many of the difficulties of the old type. For example, the starting difficulty is altogether got rid of, because the method of operating the valve is absolutely positive, and whether the face is gummy or not, the valve must open and allow a charge into the combustion chamber. Again, all the trouble as regards springs is overcome. With the old system perfection could not be obtained unless some means were possible of automatically regulating the tension of the inlet valve spring to suit the speed of the engine, and the different conditions that obtain on the suction and compression stroke, On the suction stroke the spring should be weak; on the compression stroke strong, and when the engine is running slowly, the spring should be weaker on the suction stroke than when the engine is running fast. Needless to say, it would be impossible to attain this end, but with a mechanically operated inlet valve, the same result is reached, for no matter what the conditions, the inlet valve

is bound to open and shut exactly at the right moment. This, especially in the case of a high-powered engine, is calculated to maintain the power of the engine at its maximum, and probably gives a little increased power, as compared with the old system, even when the valve springs of the latter are at exactly the right tension. Good results are therefore obtained by the new system without any special attention on the part of the driver, provided the valves are kept reasonably clean, and ground when they need it, so as to ensure good compression. As a set-off against this, there is increased complication in an extra cam shaft and gear wheels, and consequently increased expense of manufacture. Derangements are not so likely to occur as in the old system. If they do, however, they cannot be set right on the roadside.

TYRES

The life of the tyres depends largely on their being pumped correctly. The tyres should be pumped so that when the car is fully loaded the depression where they touch the ground is barely appreciable. Rust on the edges of the rim may damage the rubber, and consequently the rim should be kept clean. A burst tyre is generally the result of a previous gash which, having been neglected, has allowed water to penetrate, and so rot the fabric. Gashes and cuts should be mended immediately after they occur. The stopping

MR J. B. DUNLOP'S 10-H.P. ARGYLE CAR

material supplied by Mr F. Westwood, of Milk Street, Birmingham, is generally effective. If a burst occurs, it can be temporarily repaired by means of strong canvas placed between the air tube and the cover, and extending some inches outside the edges of the cover. It should be worked with the hand until it fits exactly the internal circumference of the cover. Then the air tube should be blown up, and the edges of the cover will grip the canvas. If after a tyre has been blown up, the spot where the burst has occurred is either smaller or greater in diameter than the other portion of the tyre, it may be taken for granted that the canvas has not been properly placed, and the tyre should be deflated and the operator try again. In mending punctures, the surface of the air tube and of the patch should be thoroughly cleaned with sand-paper, or petrol, and the thinnest possible layer of solution should be spread over both. It should be left to dry until it will not adhere to the finger, and should then be firmly pressed into position. The drying operation will take from fifteen to twenty minutes.

BRAKES

These should be examined at regular intervals, and when adjustment becomes necessary it should be at once carried out. Very often, through faulty adjustment the brake rubs and creates friction. This can be told at once by feeling the

drum for heat after the car has run a short distance. If oil gets on the surface, it should be cleaned off with petrol. An application of slaked lime is also effective.

CHAINS

These should be taken off after every few hundred miles, soaked in paraffin for an hour or two, hung up to dry, wiped clean, and then soaked in a mixture of melted tallow and black-lead. After this they should again be hung up to dry and to allow the superfluous tallow to flow off. In addition to this treatment, the chains should get a daily application of Rangraphine, a preparation supplied by Messrs Price's Patent Candle Co., of Battersea, London.

WOLSELEY 30-H.P. MOTOR, WITH FOUR-SEATED TONNEAU

Temporary Derangement

THE association between this chapter and the one which precedes it, is very close, for the simple reason that if the car is properly looked after by the motorist, he will have very few roadside troubles indeed. The two chapters, therefore should be studied in conjunction.

I shall first deal briefly with a few of the results which follow defects or neglect, and shall then deal with the failures which produce these results. The great difficulty which faces the beginner is to make a correct diagnosis of troubles which unexpectedly occur, because there may be a great number of symptoms common to many failures. There is one point in particular which I would strongly urge upon my readers, which is, that in the case of a derangement or failure, it is of vital importance to restart the engine after each adjustment or attempt to locate the trouble, for if this is not done, the operator will be no wiser as to the actual cause of the trouble, and his experience will not be increased. On the other hand, if he tests the car after each operation, he thereby locates the exact source of the trouble, and when it next occurs, the symptoms being familiar, he can hit upon it at once.

FAILURE TO START

This is one of the very first troubles that faces the beginner, and it is one which often leaves him completely non-plussed. In many cases, it is due to the ignition,—either the battery is run down, the connections are dirty, or loose; the sparking plug is fouled, or the commutator is dirty. These various troubles are dealt with under "Short Circuits." The valves, too, are a fruitful source of trouble. If they are gummy, the inlet valve sticks to its seating and will not allow a charge to be admitted. A spring may be displaced or broken, or the exhaust valve may be stuck up, or its stem broken. The carburation, also, may be at fault. Frequently, the beginner forgets to turn on the petrol, or there may be stale petrol in the carburetter, or the mixture may be incorrect. Excessive cold, preventing vaporization, or water in the petrol, will have the same result. The carburetter may be empty, or the jet choked. Bad compression, too, may prevent the engine from starting.

LOSS OF POWER AND EVENTUAL STOPPAGE

Troubles in their initial stage generally result in sluggish running, and often end up in the engine stopping altogether. The causes of both

WOLSELEY 20-H.P EIGHT-SEATED SHOOTING BRAKE

troubles are very similar, and often the mere fact of the engine running sluggishly will accentuate such a trouble as bad lubrication, or defective water circulation. The engine consequently gets gradually hotter and hotter until at last it comes to a standstill.

As in the case of failure to start, the ignition is the most fruitful source of trouble. An exhausted battery will cause sluggish running, followed by stoppage, and though the car may start again after a few minutes, the same programme will be repeated. If a wire is disconnected or broken, or a plug broken, the car will stop suddenly. An intermittent short circuit, however, will produce sluggish running, with misfires, and a wrongly adjusted or dirty contact breaker will have the same result.

Carburation often causes sluggishness; the usual troubles consist of dirt or water in the carburetter; supply pipe choked or of insufficient power; jet choked, of insufficient size, or frozen; filter choked; stale petrol; float punctured; valve spindle bent or worn; vacuum in supply tank, through want of air inlet, in case of gravity feed.

Total stoppage is often caused by water in the petrol; by the supply pipe, jet or carburetter filter being absolutely choked up with dirt; by petrol not being turned on, or by the petrol running out. The latter failure invariably happens

suddenly, and without any previous warning whatever.

The valves if dirty or pitted will cause sluggish running, or valve springs which have lost their temper or have become too weak will have the same effect. Broken or displaced valves, or broken springs will cause a stoppage.

The circulation is another cause of trouble. It may become defective through the pipes becoming air locked, or steam bound, or the pump getting out of order. The engine will then get over-heated, and if this reaches an extreme stage, will stop altogether, while in some cases, the piston will seize, and even the connecting rod break. Sluggish running will also result from bad compression, excessive lubrication, want of lubrication, or defective clutch.

SHORT CIRCUITS

Under this heading we shall include practically all ignition troubles. It should be borne in mind that the electric current will always seek to get back to the battery by the path which affords the least resistance, and consequently any weakness in the electric system will lead to the current escaping to the frame of the vehicle and returning to the battery in this manner. Needless to say, the spark in the combustion chamber will then fail. If the battery is supplying at the rate of in or about 5 amperes at 4 volts, it may be

THE ORMONDE BICYCLE WITH FORE-CARRIAGE

taken for granted that the source of the supply is correct, and the trouble may be looked for elsewhere. In the chapter on the "Care of the Car," we have described the method of testing the battery. We would urge upon our readers, however, the importance of always carrying two batteries, and in case of a failure, to switch on the second. If the car runs satisfactorily with the new battery, it may be taken for granted that the one in use was run down. But if the trouble still continues, it will be necessary to look elsewhere. The wires are the first point which need attention. A loose connection will cause a short circuit. If the connections are tight, however, the various contacts—that is the point where these connections make contact with the terminals—should be examined for wet, oil, mud, grease, etc., and if the bearing surfaces are dirty, they should be carefully scraped and cleaned. Very often it will be found that the contacts of the battery connections are corroded from the action of the acids, and need cleaning. Failing these points, the fault may be in the insulation of the wires, and each length should be examined closely, to make sure that it has not been worn through running against any portion of the frame, or burnt by the engine or exhaust pipe. If such a lesion is found, the defective spot should be bound with insulating tape, or the wire run through a rubber tube.

A careful examination should be made also to see that the wires do not actually touch any metal portion of the frame, and if they do, they should be bound out of contact, or else run through a rubber tube. If one has still reason to think that there is a short circuit in the wires each length should be tested by disconnecting one end and attaching to it one wire from the voltmetre, and attaching the other wire from the voltmetre to the opposite pole of the battery. If the voltmetre indicates a lower voltage than when its wires are attached to the terminals of the battery, there must be a short circuit. In some cases it will be found that the wire is broken inside the insulation. The spot may be located by bending the wire piece by piece.

The contract breaker (I refer to the make and break system used on the De Dion and such like engines, as distinct from the Wipe system) is often a source of trouble. The platinum points must be kept absolutely clean and the adjustment must be correct. In the case of the De Dion, the set screw must be adjusted until the platinum point rests lightly against the platinum point on the trembler. In the positive type, such as is fitted to the Aster engine, the contact should be firm. In each particular engine, however, the adjustment necessary to give the best results may slightly vary and can only be learnt by experiment. The wearing of the ebonite, pear-shaped frame, will

THE ORMONDE TANDEM BICYCLE

cause a short circuit, or it may split through the over-tightening of one of the screws, with the same result. Such short circuits may often be located by testing the engine in the dark.

The commutator, by which we distinguish the Wipe system, should be oiled with thin bicycle oil, and should be kept clear from dirt and thick foul oil.

The sparking plug is a very frequent source of trouble, and there are difficulties in the way of testing it, due to the fact that although a good spark may pass when the plug is removed from the combustion chamber, it may fail altogether under working conditions, for the heat and the compression of the mixture round the plug increases the resistance, and causes the current to seek an easier passage. At the same time, the fatness of the spark even in the ordinary atmosphere is some criterion, and of course if no spark passes at all, it is a sure index of failure. Consequently it is advisable to disconnect the wire, having first switched off the current, remove the plug from the combustion chamber, connect the wire up again, and place the plug on the metal portion of the frame, or on the top of the combustion chamber, so that only the metal portion of the body of the plug is in contact. Then switch on the current, and turn the starting handle. If no spark, or a very weak spark passes, it is a sure index of failure. Very frequently the sole and only source of trouble is

to be found in the points of the wire being fouled or oxydised, or being too far apart. The distance between the points should be, roughly speaking, one millimetre, or about the thickness of a visiting card. The exact distance, however, can only be found by experiment, as it depends largely on the compression of the engine. Also, it is well to bear in mind that when the battery is fully charged, and the voltage high, the spark may be powerful enough to pass over a comparatively wide gap, but when the battery is failing, the voltage is not sufficient to enable the spark to pass. In this case, the difficulty may be got over by pressing the points closer together. The trouble may be caused by actual defects in the plug. For example, if the core is broken, the spark will penetrate the crack where the insulation is weak, and make a short circuit with the metal cover, instead of passing at the points. Or the accumulation of oil or water on the base of the porcelain or between the sparking points, will have the same result.

The battery, needless to say, often causes trouble, which is mistaken for a short circuit, but this is dealt with under "Care of the Car."

MISFIRES AND EXPLOSIONS

These are generally caused through faulty ignition, due to short circuits or some other defect, or else to defective carburation.

THE WERNER BICYCLE

KNOCK

Too early firing is the most usual cause, but it may also arise from a looseness in the gudgeon or crank pin, or wear in the bearings of the crank shaft. Want of lubrication and overheating will also have the same result.

OVERHEATING

This is caused by a failure in the water circulation, or else defective lubrication. The first symptoms are a smell of burning and an odour of hot metal, accompanied by smoke from the exhaust, and a slight knock from the engine. The engine should be stopped at once, and the bonnet taken off to allow it to cool. Cold water should not be put into the tank until the engine has been allowed to cool, or it may result in a fracture to the water-jacket or cylinders.

Very often it will be found that the pump is defective, or may cease to act altogether. The water gauge, if fitted, is a good index, otherwise one can generally tell by touching the engine or pipes. Sometimes a pipe will burst or break. It can be temporarily repaired by means of a length of rubber tubing wired into place.

BAD COMPRESSION

This will at once affect the running of the engine. The simplest way to test the compression is by

the starting handle. If there is little resistance, it may be taken that the compression is defective.

The trouble may arise from the following causes:—Pitted valves; broken valves; leak at the base of the sparking plug, or through the washer shrinking; piston rings not properly lubricated, or stuck through burnt oil; porous head; leaky joints; bad lubrication.

THE VALVES

These frequently give trouble, and this is fully dealt with under "Care of the Car."

THE CLUTCH

A slipping clutch is a frequent source of trouble. The trained ear will always be able to tell if while the engine is running fast the car is not travelling at a correspondingly rapid speed. Also the friction will cause heat to the clutch and if the driver is in doubt, he can tell by touching it with his hand.

A plentiful supply of petrol should be squirted in to remove the oil, and then powdered resin or slaked lime applied to the bearing surfaces. If this does not put matters right, the compression spring may need adjusting.

And now a final word of warning. If roadside troubles are to be avoided, the motorist should make it an invariable rule never to travel abroad

DE DION-BOUTON 8-H.P. CAR, WITH TONNEAU CARRIAGE BODY WITH DETACHABLE CAB TOP

without a very complete outfit of tools, and a plentiful supply of spare parts, such as valves, valve springs, sparking plugs, and such like. In the case of each car, the makers, if requested, will give a list of the extras which it is advisable to carry.

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